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A.S.T.M. STANDARDS

on

ADHESIVES

Sponsored by

A.S.T.M. COMMITTEE D-14

on Adhesives

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JANUARY, 1950

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AMERICAN SOCIETY FOR TESTING MATERIALS

1916 Race St., Philadelphia 3, Pa.

THE A.S.T.M.

Purpose —*The promotion of knowledge of the materials of engineering and the standardization of specifications and the methods of testing.*

THE work of the American Society for Testing Materials, a national technical society, is carried out in two ways. "Promotion of knowledge of engineering materials" is effected through investigations by committees and individual members of the Society and by joint researches with other organizations, the results of which are presented as reports and technical papers at Society meetings, and subsequently published. A.S.T.M. committees now have more than 100 research projects under way.

The development of standards is carried out by the some 70 technical committees, each of which functions in a prescribed field and under definite regulations to insure adequate representation of producers, consumers, and general interests. The Society has formulated over 1500 standard specifications and methods of tests which are widely used in industry. Acceptance of proposed standards for publication and their adoption is by action of the Society upon recommendation of the committees.

The several classes of Society membership are: Honorary, Sustaining, Company and Individual, Junior, and Student. Membership may be held by persons, corporations, firms, technical or scientific societies, teaching faculties, libraries, etc. All members, with the exception of student members, receive the regular publications of the Society which include: the yearly *Proceedings* containing committee reports and technical papers (approximately 1300 pp.); Book of A.S.T.M. Standards, any one of six parts with all parts furnished at nominal annual charges; Index to A.S.T.M. Standards and Tentatives; ASTM BULLETIN; Year Book; and Preprints. Special prices to members are effective on most Society publications.

The membership has grown from a nucleus of 70 in 1898 when the Society was formed to more than 6000 individuals and organizations. The present membership represents all parts of the United States, Canada, South American countries, and many other foreign countries. Every major industry is represented.

There is great need for the research and standardization work the Society carries on and the active participation of all who are interested in materials is welcomed. Further information regarding membership and the activities of the Society may be obtained by addressing A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

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Adhesives

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Tentative Method of Test for

RESISTANCE OF ADHESIVE BONDS TO CHEMICAL REAGENTS[1]

A.S.T.M. Designation: D 896 – 46 T

ISSUED, 1946.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method is intended for the testing of all types of adhesives for resistance to chemical reagents. It includes provisions for reporting loss in strength in accordance with A.S.T.M. methods of test for strength properties of adhesives (Note).

NOTE.—See the A.S.T.M. Methods of Test for Tensile Properties of Adhesives (D 897),[3] for Peel or Stripping Strength of Adhesives (D 903),[3] for Strength Properties of Adhesives in Shear by Compression Loading (D 905),[3] for Strength Properties of Adhesives in Plywood Type Construction in Shear by Tension Loading (D 906),[3] for Impact Strength of Adhesives (D 950),[3] for Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal) (D 1002),[3] and for Cleavage Strength of Metal-to-Metal Adhesives (D 1062).[3] Methods of test covering other strength properties are in process of formulation by Committee D-14 on Adhesives.

Apparatus

2. (*a*) The apparatus shall consist of containers for test specimens and a cabinet for maintaining a temperature between 25 and 30 C. (77 and 86 F.).

NOTE.—Care shall be exercised in choice of materials with respect to adherend and containers in that they are unaffected by the chemicals and solvents used in the test.

(*b*) Apparatus for making strength tests is specified in the method for the property to be measured (see Note, Section 1).

Standard Reagents[4]

3. (*a*) *Sulfuric Acid* (*30 per cent*).—Slowly add 199 ml. (366 g.) of H_2SO_4 (sp. gr. 1.84) to 853 ml. of water.

(*b*) *Sulfuric Acid* (*3 per cent*).—Slowly add 16.6 ml. (30.6 g.) of H_2SO_4 (sp. gr. 1.84) to 988 ml. of water.

(*c*) *Sodium Hydroxide Solution* (*10 per cent*).—Dissolve 111 g. of NaOH in 998 ml. of water.

(*d*) *Sodium Hydroxide Solution* (*1 per cent*).—Dissolve 10.1 g. of NaOH in 999 ml. of water.

(*e*) *Ethyl Alcohol* (*95 per cent*).—Undenatured ethyl alcohol.

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, September 9, 1946.

[3] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

[4] Directions for preparation of reagents are for approximately 1-liter quantities. All percentages are by weight.

(*f*) *Ethyl Alcohol* (*50 per cent*).—Add 598 ml. (482 g.) of 95 per cent undenatured ethyl alcohol to 434 ml. of water.

(*g*) *Acetone.*

(*h*) *Ethyl Acetate, c.p.*

(*i*) *Ethylene Dichloride.*

(*j*) *Carbon Tetrachloride, c.p.*

(*k*) *Toluene.*

(*l*) *Heptane.*—Commercial grade, boiling range 90 to 100 C.

(*m*) *Sodium Chloride Solution* (*10 per cent*).—Add 107 g. of NaCl to 964 ml. of water.

(*n*) *Distilled Water.*—Freshly prepared.

Supplementary Reagents[4]

4. (*a*) *Nitric Acid* (*10 per cent*).—Add 108 ml. (153 g.) of HNO_3 (sp. gr. 1.42) to 901 ml. of water.

(*b*) *Hydrochloric Acid* (*10 per cent*).—Add 239 ml. (283 g.) of HCl (sp. gr. 1.19) to 764 ml. of water.

(*c*) *Acetic Acid* (*5 per cent*).—Add 48 ml. (50.5 g.) of glacial acetic acid (sp. gr. 1.05) to 955 ml. of water.

(*d*) *Oleic Acid, c.p.*

(*e*) *Ammonium Hydroxide* (*10 per cent*).—Add 375 ml. (336 g.) of NH_4OH (sp. gr. 0.90) to 622 ml. of water.

(*f*) *Sodium Carbonate Solution* (*2 per cent*).—Add 55 g. of $Na_2CO_3 \cdot 10H_2O$ to 964 ml. of water.

(*g*) *Hydrogen Peroxide Solution* (*3 per cent, or U.S.P. 10 volume*).—Add 98 ml. (108 g.) of commercial grade (100 volume or 28 per cent) hydrogen peroxide to 901 ml. of water.

NOTE.—Additional reagents may be substituted for or supplemented to those listed in Section 4 on agreement between the purchaser and the manufacturer, provided such reagents are within the general scope of this method.

Test Specimens

5. The test specimens shall be identical with those required in A.S.T.M. methods of test for the strength properties to be measured (see Note, Section 1).

Procedure

6. (*a*) Each specimen shall be placed in a separate container and totally immersed in a sufficient quantity of the reagent for 7 days at a temperature between 25 and 30 C. (77 and 86 F.) (Note). The specimen shall be placed on edge in the container in the case of flat specimens so that it is supported at an angle from the bottom and side wall of the container. The reagent shall be stirred every 24 hr. by moderate manual rotation of the container.

NOTE.—Choice of an alternate test temperature is permissible upon agreement between the purchaser and the manufacturer.

(*b*) The individual specimen shall be removed from the reagent, the aqueous solution rinsed off with distilled water and wiped with a clean dry cloth. The strength of the specimen shall then be determined immediately at a temperature between 25 and 30 C. (77 and 86 F.) in accordance with the specified A.S.T.M. method (see Note, Section 1).

Report

7. The report shall include the following information for each adhesive tested in all the standard reagents and any specified supplementary reagents:

(*1*) Strength property of each specimen,

(*2*) Percentage change in average strength during immersion for 7 days calculated to the nearest 0.01 per cent, taking the average strength property of untreated test specimens as 100 per cent.

(*3*) General appearance and behaviour of each specimen during and after immersion,

(*4*) Type of specimen,

(*5*) Trade name and type of adhesive used,

(*6*) A.S.T.M. designation of materials and test procedure used, and

(*7*) Application, drying, and curing conditions used in preparing specimens.

Standard Method of Test for

TENSILE PROPERTIES OF ADHESIVES[1]

A.S.T.M. Designation: D 897 – 49

ADOPTED, 1949.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 897; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

INTRODUCTION

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to insure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding which are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

Scope

1. This method of test is intended for determining the comparative tensile properties of adhesives when tested on standard shape specimens and under defined conditions of pretreatment, temperature, and testing machine speed.

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Prior to adoption as standard, this method was published as tentative from 1946 to 1949, being revised in 1949.

Description

2. Tensile strength is the maximum tensile load per unit area of original cross-section carried by a test specimen of the types herein described during a tension test. It is expressed in pounds per square inch.

Apparatus

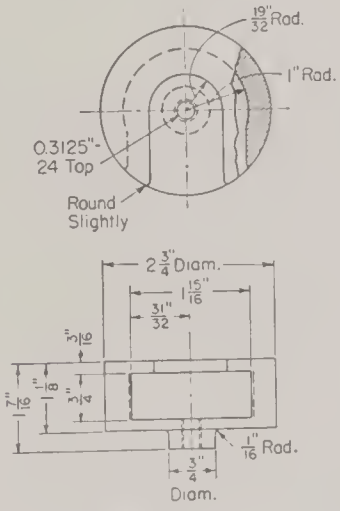
3. The apparatus shall consist of the following:

(*a*) *Testing Machine.*—A testing machine capable of maintaining a specified rate of loading and comprising essentially the following:

(*1*) *Fixed Member.*—A fixed or essentially stationary member, carrying one grip.

(*2*) *Movable Member.*—A movable member, carrying a second grip.

(*3*) *Grips.*—Grips for holding a test specimen between the fixed member and the movable member. These shall be of the self-aligning type. That is, they shall be attached to the fixed and movable member, respectively, in such a way that they will move into alignment as soon as any load is applied, so that the long axis of the test specimen will coincide with the direction of the applied pull through the center line of the grip assembly. While the design of grips of this type is optional one that has been found satisfactory is shown in Fig. 1.



Corrosion Preventive Finish

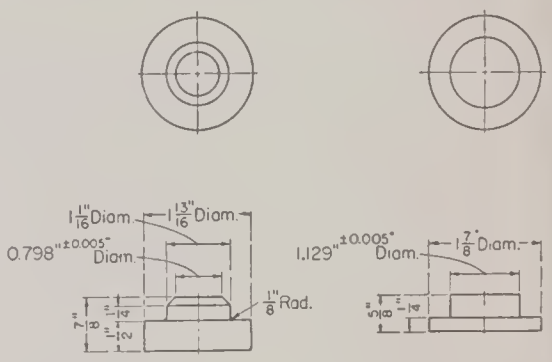
FIG. 1.—Test Grips (Cold-Rolled Steel).

(*b*) *Conditioning Room or Desiccators.*—A conditioning room capable of maintaining a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F., or desiccators filled with a saturated salt solution (Note) to give a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F.

NOTE.—A saturated salt solution of calcium nitrate will give approximately 51 per cent relative humidity at the test temperature.

Test Specimens

4. (*a*) Test specimens for wood-to-wood adhesives shall conform to the form and dimensions shown in Fig. 2 (*a*). Hard maple (*acer saccharum or acer nigrum*) having a minimum specific gravity of 0.65 based on oven-dry weight and volume, shall be used. This wood shall be of straight grain and free from defects including small knots, birdseye, short grain, and unusual discolorations within the test area. Blocks $2\frac{1}{2}$ in. in width, 11 in. in length, and $\frac{7}{8}$ in. in thickness, from which test specimens are to be made, shall be surfaced immediately before gluing, and may be conditioned prior to surfacing as recommended by the manufacturer. If no moisture conditioning process is recommended by the manufacturer, blocks at the time of surfacing shall be at equilibrium condition (Section 6 (*a*))



(*a*) Wood Specimen (Hard Maple).

(*b*) Metal Specimen

FIG. 2.—Test Specimens.

NOTE.—Surfaces of metal specimens shall be ground flat and parallel. It is preferable to grind all metal specimens at the same time.

resulting from exposure to a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F. The blocks shall be surfaced by the standard procedure as follows: Blocks shall be weighed and assembled in pairs so that blocks of approximately the same specific gravity are glued together. The blocks shall be planed smooth, preferably with a hand-feed jointer, and the surfaced faces laid together. The surfaces shall be planed just before gluing, left unsanded, and shall be free from dirt. Blocks shall then be glued as described in Section 5 and conditioned to their original moisture content, after which test specimens conforming to Fig. 2 (*a*) shall be prepared. For machining to the dimensions specified in Fig. 2 (*a*) pieces 2 by 2 in. shall be sawed from the glued hard maple block.

(*b*) Test specimens for metal-to-metal adhesives shall conform to the form and dimensions shown in Fig. 2 (*b*). Metal specimens may be reused after testing by resurfacing by grinding flat and parallel those areas which contain the adhesive. Metals conforming to the following specifications of the American Society for Testing Materials are recommended:

Metal	A.S.T.M. Designation[a]
Brass	B 16
Copper	B 133, type A
Aluminum	B 211, alloy CG21
Steel	A 108, grade 1020
Phosphor bronze	B 139, grade B2
Magnesium	B 107, alloy AZ61X or M1
Nickel Silver	B 151, alloy B

[a] These designations refer to the following specifications:
Specifications for Free-Cutting Brass Rod and Bar for Use in Screw Machines (A.S.T.M. Designation: B 16),[3]
Specifications for Copper Rods, Bars, and Shapes (Tentative) (A.S.T.M. Designation: B 133),[3]
Specifications for Aluminum and Aluminum-Alloy Bars, Rods, and Wire (Tentative) (A.S.T.M. Designation: B 211),[3]
Specifications for Cold-Finished Carbon-Steel Bars and Shafting (Tentative) (A.S.T.M. Designation: A 108),[4]
Specifications for Phosphor Bronze Rods, Bars, and Shapes (Tentative) (A.S.T.M. Designation: B 139),[3]
Specifications for Magnesium-Base Alloy Bars, Rods, and Shapes (Tentative) (A.S.T.M. Designation: B 107),[3] and
Specifications for Copper-Nickel-Zinc Alloy Rods and Bars (Tentative) (A.S.T.M. Designation: B 151).[3]

[3] 1949 Book of A.S.T.M. Standards, Part 2.
[4] 1949 Book of A.S.T.M. Standards, Part 1.

(*c*) At least 10 and preferably 20 specimens shall be tested for each adhesive in the case of wood-to-wood adhesives. At least 10 test specimens shall be tested for each adhesive in the case of metal-to-metal adhesives.

(*d*) Specimens that break at some obviously fortuitous flaw remote from the glue line shall be discarded and retest made, unless such flaws constitute a variable the effect of which it is desired to study.

Gluing

5. (*a*) Gluing shall be done in accordance with the procedure as outlined by the manufacturer of the adhesive.

(*b*) For wood specimens a pair of maple blocks, selected as described in Section 4 (*a*), 2½ in. in width, 11 in. in length, and ⅞ in. in thickness shall be glued together with the grain of the wood parallel in each piece.

(*c*) For metal specimens preparation of areas which are to be cemented shall be in accordance with the recommendations of the manufacturer of the adhesive.

Conditioning

6. (*a*) Unless otherwise agreed upon by the purchaser and the manufacturer, all wood specimens shall be preconditioned by exposure to a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F. until they reach equilibrium, as determined by no progressive change in weight.

(*b*) Preconditioning is not required for metal-to-metal bonds. The adhesive is ready for test when it has been applied in accordance with Section 5.

(*c*) Special conditioning procedures may be used by agreement between the purchaser and the manufacturer.

Procedure

7. (*a*) It is preferable that the testing be carried out under the same conditions as prescribed in Section 6.

(*b*) The specimen shall be placed in the grips of the testing machine, care being taken to align the specimen and the grips with an imaginary line joining the points of attachment of the grips to the machine. Wood-to-wood specimens shall be inserted so that the grain direction is at right angles to the long horizontal axis of the slots in the grip. Loading of the specimen should be started as quickly as possible.

(*c*) *Speed of Testing.*—Tension tests for all materials shall be made by applying a load to the specimen of 600 to 700 lb. per min., or the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. per min. (1.27 mm. per min.) when the machine is running idle.

(*d*) *Record.*—Record the maximum load carried by the specimen at failure and also the following:

(*1*) In the case of wood-to-wood adhesives record the percentage of glue failures, wood failures, and contact failures. This will be based on a visual inspection.

(*2*) In the case of metal-to-metal adhesives record the percentage of cohesion, adhesion, and contact failures (Note). This will be based on a visual inspection.

NOTE.—Cohesive failure may be obtained by observing how much of the failure has occurred in the adhesive itself. That is, if the cement has adhered to the metal test pieces and no voids are visual, it represents a 100 per cent cohesive failure. Adhesion failure refers to the lack of adhering to metals being fastened. Contact failure refers to lack of glue lines being in contact due to uneven surfaces, poor pressure distribution, etc.

Calculations

8. (*a*) Tensile strength of the wood-to-wood specimens shall be calculated by multiplying the breaking load by two. This result shall be expressed in pounds per square inch and if possible reported to three significant figures.

(*b*) Tensile strength of the metal-to-metal specimens shall be the breaking load and shall be expressed in pounds per square inch and if possible reported to three significant figures.

(*c*) For each series of tests the arithmetic mean of all the values obtained shall be calculated and reported as the "average value."

Report

9. The report shall include the following:

(*1*) Complete identification of the material tested, including types, source, manufacturer's code numbers, form, etc.,

(*2*) Method of preparing test specimens,

(*3*) Conditioning procedure used,

(*4*) Testing room conditions,

(*5*) Number of specimens tested,

(*6*) Speed of testing, and

(*7*) Average value of the tensile strength, with an average value of the percentage of glue failure for the wood specimens or cohesion failure for the metal specimens.

Tentative Method of Test for

APPLIED WEIGHT PER UNIT AREA OF DRIED ADHESIVE SOLIDS[1]

A.S.T.M. Designation: D 898 - 47 T

ISSUED, 1947.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method of test covers a procedure for determining the quantity of adhesive solids applied in a spreading or coating operation.

Description of Terms

2. (*a*) *Spreading or Coating Weight Per Unit Area* is the total quantity of adhesive solids uniformly applied, expressed in pounds per thousand square feet of joint or surface area.

(*b*) *Total Quantity of Adhesive Solids Applied* is the solvent-free gross weight of adhesive on the surface or at the glue joint, whether resulting from a single spread, double spread (both contacting surfaces spread) or multiple applications of adhesive.

(*c*) *Test Specimen or Adherend* is that material which is to be spread or coated with adhesive.

Apparatus

3. (*a*) The apparatus shall consist of a balance capable of weighing the material accurately to the nearest per cent, and a suitable instrument for measuring the linear dimensions of the specimens to the same degree of precision.

(*b*) Equipment capable of satisfactorily drying the spread or coated specimens to the solvent-free condition shall be employed.

Test Specimens

4. (*a*) Adherend test specimens shall be selected from portions of the actual material to be coated or spread, or, shall be selected from the same, or a similar lot, having the same physical characteristics such as thickness, density, texture, etc.

(*b*) The size of the test specimen may vary with the nature of the material to which the adhesive is to be applied. Materials of low porosity may normally require larger test specimens than materials of high porosity.

(*c*) Test specimens shall be of simple geometric shape to facilitate precise measurement of dimensions.

(*d*) For operations involving the coating or spreading of sheeted stock, individual plies or lamina of the adherend, a minimum of five coated and uncoated

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, February 24, 1947.

duplicate specimens shall be required for determining the average weight of adhesive solids applied.

(*e*) For operations wherein the adherend test specimen is in continuous form, such as roll stock of paper, fabric, etc., the total area of test specimens required shall be sufficient to reflect accurately the average weight of adhesive solids applied per thousand square feet of coated surface.

Conditioning

5. The test specimens shall be exposed so as to reach equilibrium with the atmospheric conditions prevailing under actual, or contemplated, operational use, prior to the application of the adhesive.

Procedure

6. (*a*) The linear dimensions of the test specimens shall be determined and their areas calculated to an accuracy of 1 per cent. The weight of the test specimens shall be determined to the nearest 1 per cent.

(*b*) The adhesive shall be applied in accordance with the procedure recommended by the manufacturer.

(*c*) Only test specimens reflecting a normal uniform application of adhesive (by visual inspection) shall be used in calculating the weight of adhesive solids applied.

(*d*) Both coated and uncoated test specimens shall be simultaneously dried to the solvent-free condition using the procedure recommended by the adhesive manufacturer.

(*e*) The solvent-free, coated and uncoated specimens, shall be reweighed. For continuous operations (where adherend test specimens are fed from roll stock) the dried, solvent-free, coated specimens shall be weighed. The weight of an equal area of identical, uncoated stock shall be established.

Calculations

7. (*a*) The weight of adhesive solids applied, where it is possible to provide exact duplicate specimens for this determination, shall be calculated as follows:

When W_2 and W_1 are expressed in grams:

$$D = \frac{(W_2 - W_1) \times 317.5}{N \times A}$$

When W_2 and W_1 are expressed in ounces:

$$D = \frac{(W_2 - W_1) \times 9000}{N \times A}$$

where:

D = weight of adhesive solids applied, expressed in pounds per thousand square feet of joint or surface areas,
W_2 = weight of the specimen after application of the adhesive and elimination of solvents,
W_1 = weight of the duplicate uncoated specimen,
A = area of test specimen in square inches, and
N = number of surfaces spread.

(*b*) The weight of adhesive solids applied, where it is not possible to provide exact duplicate specimens for this determination, shall be calculated as follows:

When W_2 and W_1 are expressed in grams:

$$D = \frac{[W_2 - W_1(1 - k)] \times 317.5}{N \times A}$$

When W_2 and W_1 are expressed in ounces:

$$D = \frac{[W_2 - W_1(1 - k)] \times 9000}{N \times A}$$

where:

D = weight of adhesive solids applied, expressed in pounds per thousand square feet of joint or surface area,

W_2 = weight of the specimen after application of the adhesive and elimination of solvents,

W_1 = original uncoated weight of the specimen,

A = area of test specimen in square inches,

N = number of surfaces spread, and

k = a factor applied to correct for changes in specimen weight that occur during the solvent elimination process. It is obtained by weighing a duplicate specimen and then exposing it simultaneously with the original coated specimen to the solvent evaporation procedure.

k is calculated as follows:

$$k = \frac{M_0 - M_1}{M_0};$$

where: M_0 = original weight of duplicate specimen, and M_1 = weight after exposure to solvent elimination.

NOTE.—For spreading or coating operations where both contacting surfaces of the joint are spread, or where successive coatings of adhesive are applied, the formulas above should be used for each surface spread or successive coating applied, and the combined weight shall equal the total weight of adhesive solids applied.

Report

8. The report shall include the following:

(*1*) Complete identification of the adhesive applied,

(*2*) Method of applying the adhesive and drying the test specimens,

(*3*) Complete description of the adherend test specimens (composition or type, moisture content, size, source, etc.),

(*4*) Number of test specimens used (or total area of test specimens if from a continuous operation) and calculated weight of adhesive solids applied to each specimen,

(*5*) The average calculated weight of adhesive solids applied per thousand square feet of joint or surface area, and

(*6*) Any qualifying remarks concerning the test procedure.

Tentative Method of Test for

APPLIED WEIGHT PER UNIT AREA OF LIQUID ADHESIVE[1]

A.S.T.M. Designation: D 899 - 47 T

ISSUED, 1947.[2]

This Tentative Method has been approvd by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method of test covers a procedure for determining the quantity of liquid adhesive applied in a spreading or coating operation.

Description of Terms

2. (*a*) *Spreading or Coating Weight per Unit Area* is the total quantity of liquid adhesive uniformly applied, expressed in pounds per thousand square feet of joint or surface area.

(*b*) *Total Quantity of Liquid Adhesive Uniformly Applied* is the gross weight of adhesive on the surface or at the glue joint, whether resulting from a single spread, double spread (both contacting surfaces spread), or multiple applications of adhesive.

(*c*) *Test Specimen or Adherend* is that material which is to be spread or coated with adhesive.

Apparatus

3. The apparatus shall consist of a balance capable of weighing the material accurately to the nearest 1 per cent, and a suitable instrument for measuring the linear dimensions of the specimens to the same degree of precision.

Test Specimens

4. (*a*) Adherend test specimens shall be selected from portions of the actual material to be coated or spread, or shall be selected from the same, or a similar lot, having the same physical characteristics such as thickness, density, texture, etc.

(*b*) The size of the specimen may vary with the nature of the material to which the adhesive is to be applied. Materials of low porosity may normally require larger test specimens than materials of high porosity.

(*c*) Test specimens shall be of simple geometric shape to facilitate precise measurement of dimensions.

(*d*) For operations involving the coating or spreading of sheeted stock, individual plies or lamina of the adherend,

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, February 24, 1947.

a minimum of five test specimens shall be required for determining the average weight of liquid adhesive applied.

(*e*) For operations wherein the adherend test specimen is in continuous form, such as roll stock of paper, fabric, etc., the total area of test specimens required shall be sufficient to reflect accurately the average weight of liquid adhesive applied per thousand square feet of coated surface.

Conditioning

5. The test specimens shall be exposed so as to reach equilibrium with the atmospheric conditions prevailing under actual, or contemplated, operational use, prior to the application of the adhesive.

Procedure

6. (*a*) The linear dimensions of the test specimens shall be determined and their areas calculated to an accuracy of 1 per cent. The weight of the test specimens shall be determined to the nearest 1 per cent.

(*b*) The adhesive shall be applied to the test specimens in accordance with the procedure recommended by the manufacturer, and the specimens immediately reweighed.

(*c*) Only test specimens reflecting a normal uniform application of adhesive (by visual inspection) shall be used in calculating the weight of liquid adhesive applied.

Calculation

7. The weight of liquid adhesive applied shall be calculated as follows:

When W_2 and W_1 are expressed in grams:

$$S = \frac{(W_2 - W_1) \times 317.5}{N \times A}$$

When W_2 and W_1 are expressed in ounces:

$$S = \frac{(W_2 - W_1) \times 9000}{N \times A}$$

where:

S = weight of liquid adhesive applied, expressed in pounds per thousand square feet of joint or surface area,
W_2 = weight of specimen immediately after application of the adhesive,
W_1 = weight of specimen before applying the adhesive,
A = area of test specimen in square inches, and
N = number of surfaces spread.

NOTE.—For bonding operations where both contacting surfaces of the joint are spread with adhesive, the formulas above should be used for each surface spread and the combined weight shall equal the total weight of adhesive applied.

Report

8. The report shall include the following:

(*1*) Complete identification of the adhesive applied,

(*2*) Method of applying adhesive,

(*3*) Complete description of the adherend test specimens (composition or type, moisture content, size, source, etc.)

(*4*) Number of test specimens used (or total area of test specimens if from a continuous operation) and calculated weight of adhesive applied to each specimen,

(*5*) The average calculated weight of liquid adhesive applied per thousand square feet of surface of joint area, and

(*6*) Any qualifying remarks concerning the test procedure.

Standard Method of Test for

PEEL OR STRIPPING STRENGTH OF ADHESIVES[1]

A.S.T.M. Designation: D 903 – 49

ADOPTED, 1949.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 903; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

INTRODUCTION

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to insure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding which are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

Scope

1. This method of test is intended for determining the comparative peel or stripping characteristics of adhesives when tested on standard sized specimens and under defined conditions of pretreatment, temperature, and testing machine speed.

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Prior to adoption as standard, this method was published as tentative from 1946 to 1949, being revised in 1949.

Description of Terms

2. (*a*) *Peel or Stripping Strength.*—The average load per unit width of bond line required to separate progressively one member from the other over the adhered surfaces at a separation angle of approximately 180 deg. and at a separation rate of 6 in. per min. It is expressed in pounds per inch of width.

(*b*) *Flexible.*—The designation "flexible" in this test indicates a material of the proper flexural strength and thickness to permit a turn back at an approximate 180-deg. angle in the expected loading range of the test without failure. In order to fulfill all terms of the definition, at least one of the adhered materials must be flexible.

Apparatus

3. The apparatus shall consist of the following:

(*a*) *Testing Machine.*—A power-driven machine, preferably of the inclination balance or pendulum type, which shall fulfill the following requirements:

(*1*) The applied tension as measured and recorded shall be accurate within plus or minus 1 per cent.

(*2*) Specimens shall be held in the testing machine by grips which clamp firmly and prevent slipping at all times.

(*3*) The rate of travel of the power-actuated grip shall be 12 in. per min. This rate which provides a separation of 6 in. per min. shall be uniform throughout the tests.

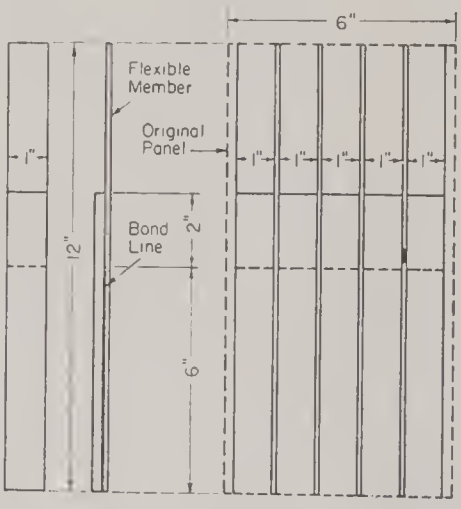
(*4*) The machine shall be operated without any device for maintaining maximum load indication. In pendulum-type machines, the weight lever shall swing as a free pendulum without engagement of pawls.

(*5*) The machine shall be autographic giving a chart having the inches of separation as one axis and applied tension as the other axis of coordinates.

(*6*) The machine shall be of such capacity that the maximum applied tension during test shall not exceed 85 per cent nor be less than 15 per cent of the rated capacity.

(*b*) *Conditioning Room or Desiccators.*—A conditioning room capable of maintaining a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F., or desiccators filled with a saturated salt solution (Note) to give a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F. are required for the conditioning of some specimens.

NOTE.—A saturated salt solution of calcium nitrate will give approximately 51 per cent relative humidity at the testing temperature.



(*a*) Test Specimen. (*b*) Specimens from Bonded Panel.

FIG. 1.—Test Specimen.

Test Specimen

4. (*a*) The test specimen, shown in Fig. 1(*a*), shall consist of one piece of flexible material, 1 by 12 in., bonded for 6 in. at one end to one piece of flexible or rigid material, 1 by 8 in., with the unbonded portions of each member being face to face.

(*b*) In order to maintain a separation rate of 6 in. per min. the specimen shall be relatively nonextensible in the expected loading range. Where a material is sufficiently extensible to lessen radically the separation rate, it shall be backed up with a suitable nonextensible

material. In reporting such a test, the backing material and method shall be completely identified.

(*c*) Test materials shall be thick enough to withstand the expected tensile pull but not over $\frac{1}{8}$ in. in thickness. Wherever possible, the standard thickness of specimens shall be: metals, $\frac{1}{16}$ in., plastics, $\frac{1}{16}$ in., woods, $\frac{1}{8}$ in., rubber compounds, 0.075 in., and cotton duck, 30 oz. per sq. yd. Other special materials, as well as the standard materials, shall be completely identified in the test report as specified in Section 9.

(*d*) At least ten test specimens shall be tested for each adhesive.

(*e*) Any specimen whose test result is out of line due to some obvious flaw shall be discarded and retest made.

Preparation of Test Specimen

5. (*a*) Any preconditioning or special preparation of the areas to be bonded shall be done in accordance with the recommendations of the manufacturer of the adhesive.

(*b*) All bonding shall be done in accordance with the procedure and recommendations as outlined by the manufacturer of the adhesive.

(*c*) While individual specimens may be prepared, it is recommended that specimens be cut from bonded panels approximately 6 in. in width as shown in Fig. 1(*b*), so that five standard 1-in. wide specimens may be obtained from each panel.

Conditioning

6. (*a*) All specimens shall be conditioned for seven days by exposure to a relative humidity of 50 ± 2 per cent at 73.4 ± 2 F. or until equilibrium is reached, except where the adhesive manufacturer may specify such an aging period to be unnecessary or a shorter period to be adequate.

(*b*) Special conditioning procedures may be used by agreement between the purchaser and the manufacturer.

Procedure

7. (*a*) Testing shall be conducted as soon as possible after removal of the test specimens from the conditioning atmosphere and preferably under the same conditions.

(*b*) The free end of the 1-in. wide flexible member shall be separated by hand from the other member for a distance of about 1 in. The specimen shall then be placed in the testing machine by clamping the free end of the 8-in. long member in one grip, turning back the free end of the flexible member and clamping it in the other grip as shown in Fig. 2. The separated end of the specimen, with all separate parts except the one under test securely gripped, shall be attached to the recording head by means of a clamp using care to adjust it symmetrically in order that the tension shall be distributed uniformly. Provision shall be made to maintain the specimen during test approximately in the plane of the clamps. This may be done either by attaching the minimum weight required to the free end of the specimen or by holding the specimen against an alignment plate (Fig. 2)

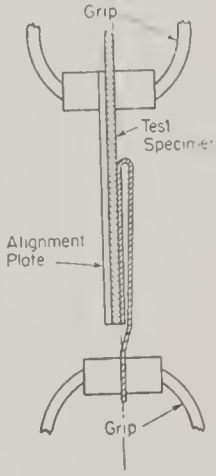


FIG. 2.—Specimen Under Test.

attached to the stationary clamp. In either case the added weight shall be taken into account in determining the load causing separation. The 1-in. wide flexible member shall be gripped symmetrically and firmly without twisting in the power-actuated clamp. The autographic mechanism and chart shall be adjusted to zero and the machine started. The separating member shall be stripped from the specimen approximately at an angle of 180 deg. and the separation continued for a sufficient distance to indicate the peel or stripping value. At least one half of the bonded area shall be peeled, even though a peel or stripping value may be indicated before this point.

Calculations

8. (*a*) The actual peel or stripping strength shall be determined by drawing on the autographic chart the best average load line which will accommodate the recorded curve. The load so indicated, corrected for any tare weight which may have been used with the specimen as described in Section 7 (*b*), expressed in pounds per inch of width for separation at 6 in. per min. shall be reported as the peel or stripping strength for the particular specimen under test.

(*b*) For each series of tests, the arithmetic mean of all the values obtained shall be calculated and reported as the "average value."

Report

9. The report shall include the following:

(*1*) Complete identification of the adhesive and specimen tested, including types, source, manufacturer's code numbers, form, etc.,

(*2*) Method of preparing test specimens,

(*3*) Conditioning procedure used,

(*4*) Testing room conditions,

(*5*) Number of specimens tested,

(*6*) Speed of testing,

(*7*) Average value of peel or stripping strength,

(*8*) Maximum and minimum strength values of the series,

(*9*) Individual test values, individual autographic charts, and other statistical data requested by the purchaser, and

(*10*) Type of failure; whether in adhesion, cohesion in the adhesive or in the material being bonded (Note).

NOTE.—Cohesive or adhesive failure may be determined by observation. A cohesive failure is one which has occurred in the adhesive or specimen material itself. Adhesive failure refers to the lack of adherence to the materials being bonded.

Tentative Recommended Practice for

DETERMINING THE EFFECT OF ARTIFICIAL (CARBON-ARC TYPE) AND NATURAL LIGHT ON THE PERMANENCE OF ADHESIVES[1]

A.S.T.M. Designation: D 904 – 46 T

ISSUED, 1946.[2]

This Tentative Recommended Practice has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. (*a*) This recommended practice is intended to define conditions for the exposure of adhesives in the form of glued transparent or translucent assemblies to (*1*) artificial and (*2*) natural light sources. Where such information is of value, the same exposure conditions may be used on adhesive film or any other suitable form in which light may be a deteriorating factor.

(*b*) This recommended practice is limited to the method of obtaining the exposure conditions and procedure to be followed, but does not cover methods of test to be used in evaluating the effects of the exposure.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Artificial Light Exposure Unit.*—The exposure unit[3] shall consist of a carbon-arc light source and suitable specimen supports, with means being provided for measuring and controlling the current-voltage of the light source, temperature of the air surrounding the specimens, and exposure cycle.

(*1*) *Light Source.*—A carbon-arc with suitable transparent globe or window.

(*2*) *Specimen Supports.*—Supports shall be provided for mounting the specimens vertically and in such a manner that uniform distribution of light is obtained at the specimen. The specimens shall be rotated around the arc to insure further uniform distribution of light. If the specimens are mounted both above and below the horizontal center line of the light source, they may be mounted at an angle with the vertical not greater than 30 deg. so that the light from the arc has a normal

[1] Under the standardization procedure of the Society, this recommended practice is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, December 31, 1946.

[3] Units which successfully fulfill all requirements of this method are the Atlas Single and Twin Arc Apparatus (Alternating or Direct Current), Atlas Fade Ometer, and the National Carbon Apparatus.

incidence upon the specimens. Specimens above and below the horizontal line shall be transposed periodically to provide uniform distribution of the light over the face of the specimens.

(*3*) *Thermometer.*—A suitable shielded thermometer for determining the temperature of the air at the position of the specimen in the drum.

(*b*) *Natural Sunlight Exposure Rack.*—The rack shall consist of any suitable framework on which the test specimens may be fastened at an angle of 45 deg. facing south. The specimens shall be protected from direct contact with other weathering elements and foreign matter by means of a transparent shield[4] which will allow transmission of normal solar radiation, but no attempt shall be made to control temperature or relative humidity surrounding the specimens. The roof of a building is a satisfactory location for an exposure rack.

Test Specimens

3. Test specimens shall be prepared and aged prior to test according to the recommendations of the manufacturer for use of the adhesive. These specimens shall be of a suitable form and number to meet the requirements of the investigation and shall conform in detail with the requirements prescribed in the Standard Method of Test for Tensile Properties of Adhesives (A.S.T.M. Designation: D 897),[5] the Standard Method of Test for Peel or Stripping Strength of Adhesives (A.S.T.M. Designation: D 903),[5] or any other A.S.T.M. method of test pertaining to strength properties of adhesives for the desired strength test or with other established test methods such as for light transmission, haze, etc. Where visual inspection or arbitrary evaluation is resorted to, the specimens may be of any designated shape and size or in the form of a film.

Method of Test

4. (*a*) *Artificial Light.*—The test specimens shall be firmly fastened in their holders and then exposed to the carbon-arc light source. Check specimens, shielded from the light source, shall also be provided to determine any degradation resulting from temperature and humidity effects rather than radiation alone. The temperature of the air surrounding the specimens shall be maintained between 35 and 50 C. as measured by the shielded thermometer. Recommended exposure time shall be 10 hr. or a multiple of 10 hr. unless a significant change can be expected in a shorter time. Exposure period may be repeated as often as desired. The units shall at all times be operated under the following conditions:

(*1*) *Atlas Single and Twin Arc Apparatus* (*Alternating Current*).—The average for each trim or burning period shall be 135 v. ± 2 per cent and 16 amp. ± 2 per cent at the arc. During the burning period, the voltage may vary between 125 and 145 v. and the amperage between 15 and 18 amp.

(*2*) *Atlas Single and Twin Arc Apparatus* (*Direct Current*).—The average for each trim or burning period shall be 135 v. ± 2 per cent and 12 amp. ± 2 per cent at the arc. During the burning period, the voltage may vary between 130 and 145 v. and the amperage between 11 and 13 amp.

(*3*) *Atlas Fade Ometer.*—Same as prescribed in items (*1*) and (*2*) above.

(*4*) *National Apparatus.*—The average for each trim or burning period shall be 50 v. ± 2 per cent and 60 amp. ± 2 per cent at the arc.

Filters (globes and windows) shall be

[4] Pyrex glass, 9200 PX, has been found satisfactory for the shield.

[5] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

replaced after 2000 hr. of use, or when pronounced discoloration or milkiness develops, whichever occurs first (Note). Filters shall be cleaned each day by washing with detergent and water.

NOTE.—The use of the Tentative Method of Calibrating a Light Source Used for Accelerating the Deterioration of Rubber (A.S.T.M. Designation: D 749),[6] is suggested for checking the uniformity of operation of the light source.

(*b*) *Natural Light.*—The specimens shall be attached to the 45 deg. angle rack and the transparent shield placed in position. Check specimens shielded from the sun shall also be provided to determine any degradation resulting from temperature and humidity effects rather than radiation alone. Specimens shall be examined at 2-week intervals and final evaluation or testing conducted at a predetermined time. A suitable exposure period is one year, although it may be shorter or longer as agreed upon by the manufacturer and the purchaser. The transparent shield shall be cleaned and inspected at least once every two weeks and replaced at the first signs of discoloration or milkiness.

[6] 1949 Book of A.S.T.M. Standards, Part 6.

Report

5. The report shall include the following:

(*1*) Complete identification of the adhesives and specimen materials used,

(*2*) Method of preparation of specimens, including thickness of glue line or film,

(*3*) Type and duration of exposure to light including a complete description of the exposure unit used for artificial light, and the geographical location, dates of the exposure period, and general climatic conditions for natural light.

(*4*) Description of any visual changes in appearance that may have occurred during each exposure period for both the test and check specimens,

(*5*) Results of any physical, chemical or other tests made to determine the extent of degradation resulting from the exposure. This shall also include tests on the check specimens. The test methods used shall be adequately described.

Standard Method of Test for

STRENGTH PROPERTIES OF ADHESIVES IN SHEAR BY COMPRESSION LOADING[1]

A.S.T.M. Designation: D 905 - 49

ADOPTED, 1949.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 905; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to insure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) The moisture content of the wood at the time of gluing.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Prior to adoption as standard, this method was published as tentative from 1947 to 1949, being revised in 1949.

Scope

1. This method of test is intended for determining the comparative shear strengths of adhesives, used for bonding wood and other similar materials, when tested on a standard specimen under specified conditions of preparation, conditioning, and loading in compression. This method is intended primarily as an evaluation of adhesives for wood.

Apparatus

2. The testing machine shall have a capacity of not less than 15,000 lb. in compression and shall be fitted with a shearing tool containing a self-aligning seat to insure uniform lateral distribution of the load. The machine shall be capable of maintaining a uniform rate of loading such that the load may be applied with a continuous motion of the movable head to maximum load at a rate of 0.015 in. per min. with a permissible variation of plus or minus 25 per cent. The shearing tool shown in Fig. 1 has been found satisfactory. The testing machine shall be located in an atmosphere such that the moisture content of the specimens developed under the conditions prescribed in Section 5 is not noticeably altered during testing.

Test Specimens

3. (*a*) Test specimens shall conform to the form and dimensions shown in Fig. 2. The specimens shall be cut from test joints prepared as described in Sections 4 and 5.

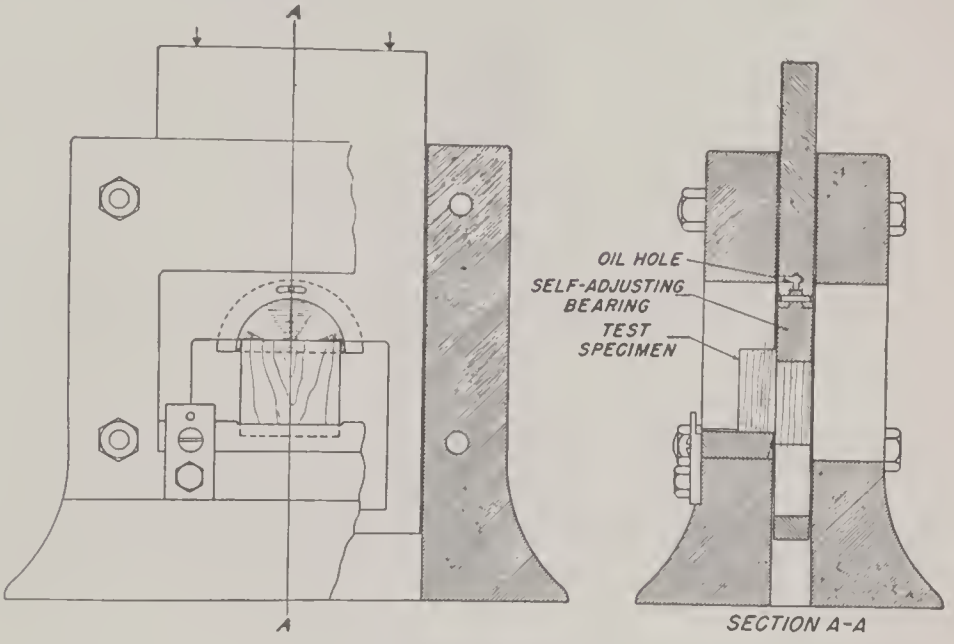

FIG. 1.—Shearing Tool.

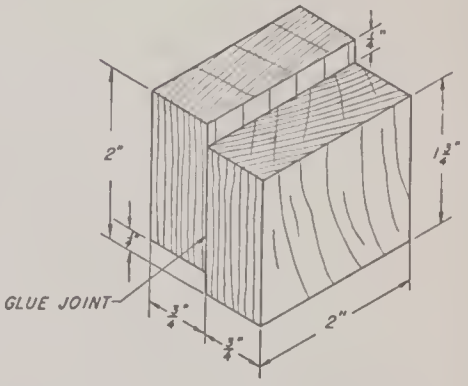

FIG. 2.—Form and Dimensions of Test Specimen.

(*b*) At least 20 specimens shall be tested, representing at least four different joints.

Preparation of Test Joints

4. (*a*) Hard maple blocks (*acer saccharum or acer nigrum*), having a minimum specific gravity of 0.65 based on oven-dry weight and volume shall be selected (Note). These blocks shall be of straight grain and free from defects including knots, birdseye, short grain, decay, and any unusual discolorations within the shearing area. The blocks shall be of suitable size preferably so that five test specimens may be cut from one test joint as shown in Fig. 3. Blocks approximately $\frac{3}{4}$ by $2\frac{1}{2}$ by 12 in. have been found to be satisfactory for this purpose. The grain direction shall be parallel to the longest dimension of the block. The blocks shall be at the equilibrium moisture content recommended by the manufacturer of the adhesive. In the absence of such recommendation, the moisture content shall be from 10 to 12 per cent based on oven-dry weight as determined on representative samples in accordance with Sections 115 to 118 of the Standard Methods of Testing Small Clear Specimens of Timber (A.S.T.M. Designation: D 143).[3] The blocks shall be surfaced, just prior to gluing, preferably with a hand-feed jointer, and the blocks weighed and assembled in pairs so that blocks of approximately the same specific gravity are glued together. The surfaces shall remain unsanded and shall be free from dirt.

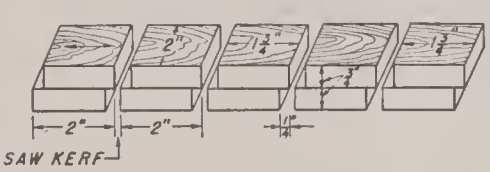

FIG. 3.—Test Joint Showing Method of Cutting Five Test Specimens.

NOTE.—A method for selecting maple blocks of satisfactory specific gravity is described in the Appendix to this method. For referee tests, the specific gravity of blocks may be determined in accordance with Section 107 of A.S.T.M. Methods D 143.

(*b*) The adhesive shall be prepared and applied to the blocks in accordance with the procedure recommended by the manufacturer of the adhesive. The glue-coated blocks shall then be assembled and pressed, likewise in accordance with the recommendations of the manufacturer of the adhesive.

Conditioning of Test Joints

5. The joints, upon removal from pressure shall be conditioned at a relative humidity of 50 ± 2 per cent and at a temperature of 73.4 ± 2 F. either for a period of seven days or until specimens reach equilibrium as indicated by no progressive changes in weight, whichever is the shorter period. The length of this period of conditioning may be extended beyond this limit by written agreement between the purchaser and the manufacturer of the adhesive.

Preparation of Specimens

6. (*a*) The specimens shall be cut as shown in Fig. 3 so that the grain direction is parallel to the direction of loading during test. Care shall be taken in preparing the test specimens to make the loaded surfaces smooth and parallel to each other and perpendicular to the height. Care shall also be exercised in reducing the lengths of the laminations to $1\frac{3}{4}$ in. to insure that the saw cuts extend to, but not beyond, the glue line. The width and length of the specimen at the glue line shall be measured to the nearest 0.010 in. to determine the shear area.

(*b*) Specimens shall be retained in the conditioning atmosphere described in Section 5 until tested, except during the cutting operations.

Procedure

7. The test specimen shall be placed in the shearing tool so that the load may be

[3] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

applied as described in Section 2. The position of the specimen in one type of shearing tool is shown in Fig. 1. The loading shall be applied with a continuous motion of the movable head at a rate of 0.015 in. per min. to failure as prescribed in Section 2.

Calculation

8. The shear stress at failure shall be calculated in pounds per square inch, based on the glue line area between the two laminations measured to the nearest 0.01 sq. in., and shall be reported for each specimen together with the estimated percentage of wood failure.

Report

9. The report shall include the following:

(*1*) Complete identification of the adhesive tested, including type, source, manufacturer's code numbers, form, etc.,

(*2*) Application and bonding conditions used in preparing the specimens,

(*3*) Conditioning procedure used for the specimens,

(*4*) Temperature and relative humidity in the test room,

(*5*) Number of specimens tested,

(*6*) Number of joints represented,

(*7*) Maximum and minimum shear stresses at failure and percentages of wood failure. The standard deviation or all individual test values, or both, for the failing load values and wood failure values may be included in the report at the option of either the purchaser or the manufacturer of the adhesive.

(*8*) The average shear stress at failure and the average percentage of wood failure.

APPENDIX

METHOD FOR SELECTING MAPLE BLOCKS OF SATISFACTORY SPECIFIC GRAVITY

Cut the hard maple blocks into some standard size such as $\frac{3}{4}$ by $2\frac{1}{2}$ by 12 in. after conditioning. Measure the linear dimensions of the blocks in inches, using a suitable caliper or other measuring device. Determine the percentage moisture content of the blocks in accordance with Sections 115 to 118 of the Standard Methods of Testing Small Clear Specimens of Timber (A.S.T.M. Designation: D 143).[3] These samples shall not be used in further tests.

Calculate the volume of the blocks to the nearest 0.1 cu. in. and express the average percentage moisture content to the nearest whole number. Determine the numerical value of the factor for this moisture content by reference to Table I, which is based on hard maple blocks that have a specific gravity of 0.65 on the oven-dry weight and volume basis and which were conditioned to various moisture content values.

The factor in Table I shall be multiplied by the volume of the block in cubic inches to obtain the weight of the block in grams which would have a specific gravity of 0.65 on the oven-dry weight and volume basis.

TABLE I.—FACTORS FOR CORRECTED WEIGHT IN GRAMS.

Moisture Content, per cent	Factor[a]
4	10.83
5	10.88
6	10.92
7	10.96
8	11.00
9	11.03
10	11.08
11	11.12
12	11.15
13	11.20
14	11.23
15	11.27

[a] These values are the weights of 1 cu. in. of sugar maple in grams, at the moisture content values indicated, which would have a specific gravity of 0.65 on the oven-dry weight and volume basis.

All blocks to be used in the test shall be weighed at this moisture content and those blocks having a weight less than the above calculated value shall not be used.

Standard Method of Test for

STRENGTH PROPERTIES OF ADHESIVES IN PLYWOOD TYPE CONSTRUCTION IN SHEAR BY TENSION LOADING[1]

A.S.T.M. Designation: D 906 – 49

ADOPTED, 1949.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 906; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to insure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) The moisture content of the wood at the time of gluing.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Prior to adoption as standard, this method was published as tentative from 1947 to 1949, being revised in 1949.

Scope

1. This method of test is intended for determining the comparative shear strengths of adhesives in plywood type construction, when tested on a standard specimen and under specified conditions of preparation, conditioning, and testing. This method is intended to be applied only to adhesives used in bonding wood to wood.

Apparatus

2. The testing machine shall be capable of maintaining a rate of loading of 600 to 1000 lb. per min. It shall be provided with suitable grips and jaws so that the specimen can be gripped tightly

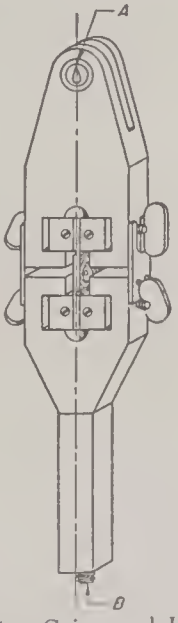

FIG. 1.—Grips and Jaws.

and held in alignment as the load is applied. The grips and jaws shown in Fig. 1 have been found satisfactory. The testing machine shall be located in an atmosphere such that the moisture content of the specimens developed under the conditions prescribed in Section 5, is not noticeably altered during testing.

Test Specimens

3. (*a*) The test specimens shall conform to the form and dimensions shown in Fig. 2. The specimens shall be cut from test panels prepared as described in Sections 4 and 5.

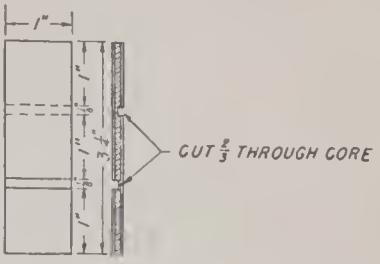

FIG. 2.—Form and Dimensions of Test Specimen.

(*b*) At least 20 specimens shall be tested, representing at least four different panels.

Preparation of Test Panels

4. (*a*) Sweet or yellow birch veneer (*Betula lenta or Betula lutea*), either rotary cut or sliced, $\frac{1}{16}$ in. in thickness,

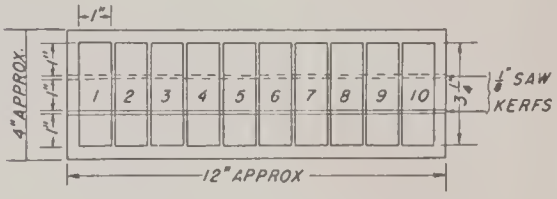

FIG. 3.—Size of Test Panel.

shall be selected so that it is free from defects such as knots, cracks, short grain, or any unusual amount of discoloration which would indicate decay. The surfaces shall be unsanded. The veneer shall be cut into suitable sizes and assembled in groups of three sheets, the grain of the center sheet running at right angles to the grain of the other two sheets. The grain in all sheets shall be parallel to one edge. A size which has been found to be convenient is shown in Fig. 3, in which case the grain in the face plies should be parallel to the shorter dimension. The veneer shall be at the moisture content recommended by the manufacturer of

the adhesive. In the absence of such a recommendation, the moisture content shall be from 10 to 12 per cent based on oven-dry weight as determined on representative samples in accordance with Sections 115 to 118 of the Standard Methods for Testing Small Clear Specimens of Timber (A.S.T.M. Designation: D 143).[3] Any other species of veneer may be substituted in these tests upon written agreement between the purchaser and the manufacturer of the adhesive.

(*b*) The adhesive shall be prepared in accordance with the procedure outlined by the manufacturer of the adhesive.

(*c*) The adhesive shall be applied to the veneers as prescribed by the manufacturer of the adhesive. After the prescribed time has elapsed, the veneers shall be assembled into three-ply panels so that the grain in the center ply is at right angles to the grain in the two outer plies. The panel shall then be pressed under the prescribed conditions.

Conditioning of Test Panels

5. The panels, upon removal from pressure, shall be conditioned at a relative humidity of 50 ± 2 per cent and at a temperature of 73.4 ± 2 F. either for a period of seven days, or until specimens reach equilibrium as indicated by no progressive changes in weight, whichever is the shorter period. The length of this period of conditioning may be extended beyond this limit by written agreement between the purchaser and the manufacturer of the adhesive.

Preparation of Specimens

6. (*a*) The test specimens shall be cut as shown in Fig. 2. This is best accomplished by cutting the notches to the proper width, depth and location in the test panel, using a hollow ground grooving saw or any other method that will give equally satisfactory results. The individual test specimens shall then be cut from the panel. The cutting of individual specimens is shown for one size of panel in Fig. 3. The width of the specimen and the distance between notches shall be measured to the nearest 0.010 in. to determine the shear area.

(*b*) Specimens shall be retained in the conditioning atmosphere described in Section 5, until tested, except during the cutting operations.

Procedure

7. The test specimen shall be placed in the jaws of the grips in the testing machine and gripped tightly so that the specimen is perfectly aligned and the pairs of jaws are directly above each other and in such a position that an imaginary straight vertical line would pass through the center of the core ply and through the points of suspension A and B as shown in Fig. 1. Specimens shall be placed in the jaws alternately so that in one case the upper notch is to the left and in the other case towards the right. The load shall then be applied at a rate of 600 to 1000 lb. per min. until failure.

Calculation

8. The load at failure and the estimated percentage of wood failure shall be recorded for each test specimen. All failing loads shall be expressed in pounds per square inch of shear area, calculated to the nearest 0.01 sq. in.

Report

9. The report shall include the following:

(*1*) Complete identification of the adhesive tested including type, source, manufacturer's code numbers, form, etc.,

(*2*) Application and bonding conditions used in preparing the specimens,

(*3*) Conditioning procedure used for the specimens,

[3] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

(*4*) Temperature and relative humidity in the test room,

(*5*) Number of specimens tested,

(*6*) Number of panels represented,

(*7*) Maximum and minimum loads at failure and percentages of wood failure. The standard deviation or all individual test values, or both, for the failing load values and wood failure values may be included in the report at the option of either the purchaser or the manufacturer of the adhesive.

(*8*) The average load at failure and the average percentage of wood failure.

Tentative Definitions of

TERMS RELATING TO ADHESIVES[1]

A.S.T.M. Designation: D 907 – 49 T

ISSUED, 1947; REVISED, 1948, 1949.[2]

These Tentative Definitions have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

A-Stage, *n.*—An early stage in the reaction of a thermosetting resin in which the material is still soluble in certain liquids and fusible. (See also *B-Stage* and *C-Stage.*)

Adhere, *v.*—To cause two surfaces to be held together by adhesion.

Adherend, *n.*—A body which is held to another body by an adhesive. (See also *Substrate.*)

Adhesion, *n.*—The state in which two surfaces are held together by interfacial forces which may consist of valence forces or interlocking action, or both. (See also *Adhesion, Mechanical* and *Adhesion, Specific.*)

Adhesion, Mechanical.—Adhesion between surfaces in which the adhesive holds the parts together by interlocking action. (See also *Adhesion, Specific.*)

Adhesion, Specific.—Adhesion between surfaces which are held together by valence forces of the same type as those which give rise to cohesion. (See also *Adhesion, Mechanical.*)

Adhesive, *n.*—A substance capable of holding materials together by surface attachment.

NOTE.—Adhesive is the general term and includes among others cement, glue, mucilage and paste. All of these terms are loosely used interchangeably. Various descriptive adjectives are applied to the term adhesive to indicate certain characteristics as follows:

Physical form, that is, liquid adhesive, tape adhesive
Chemical type, that is, silicate adhesive, resin adhesive
Materials bonded, that is, paper adhesive, metal-plastic adhesive, can label adhesive
Conditions of use, that is, hot-setting adhesive

Adhesive, Assembly.—An adhesive which can be used for bonding parts together, such as in the manufacture of a boat, airplane, furniture, and the like.

NOTE.—The term assembly adhesive is commonly used in the wood industry to distinguish such adhesives (formerly called "joint glues") from those used in making plywood (sometimes called "veneer glues"). It is applied to adhesives used in fabricating finished structures or goods, or subassemblies thereof, as differentiated from adhesives used in the production of sheet materials for sale as such, for example, plywood or laminates.

Adhesive, Cold-Setting.—An adhesive which sets at temperatures below 20 C. (68 F.). (See also *Adhesive, Hot-Setting; Adhesive,*

[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Latest revisions accepted by the Administrative Committee on Standards, September 22, 1949.

Intermediate Temperature Setting; and *Adhesive, Room Temperature Setting.*)

Adhesive, Hot-Setting.—An adhesive which requires a temperature at or above 100 C. (212 F.) to set it. (See also *Adhesive, Cold-Setting; Adhesive, Intermediate Temperature Setting;* and *Adhesive, Room Temperature Setting.*)

Adhesive, Intermediate Temperature Setting.—An adhesive which sets in the temperature range 31 to 99 C. (87 to 211 F.). (See also *Adhesive, Cold-Setting; Adhesive, Hot-Setting;* and *Adhesive, Room Temperature Setting.*)

Adhesive, Pressure-Sensitive.—An adhesive made so as to adhere to a surface at room temperature by briefly applied pressure alone.

Adhesive, Room Temperature Setting.—An adhesive which sets in the temperature range of 20 to 30 C. (68 to 86 F.), in accordance with the limits for Standard Room Temperature specified in the Tentative Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (A.S.T.M. Designation: D 618).[3] (See also *Adhesive, Cold-Setting; Adhesive, Hot-Setting;* and *Adhesive, Intermediate Temperature Setting.*)

Adhesive, Separate Application.—A term used to describe an adhesive consisting of two parts, one part being applied to one adherend and the other part to the other adherend and the two brought together to form a joint.

Adhesive, Warm-Setting.—A term which is sometimes used as a synonym for Intermediate Temperature Setting Adhesive. (See *Adhesive, Intermediate Temperature Setting.*)

Aging Time.—See Time, Joint Conditioning.

Aggressive Tack.—See Tack, Dry.

Assembly, n.—A group of materials or parts, including adhesive, which has been placed together for bonding or which has been bonded together.

Assembly Adhesive.—See Adhesive, Assembly.

Assembly Glue.—See Adhesive, Assembly.

Assembly Time.—See Time, Assembly.

B-Stage.—An intermediate stage in the reaction of a thermosetting resin in which the material softens when heated and swells in contact with certain liquids, but may not entirely fuse or dissolve. Resins in thermosetting molding compounds are usually in this stage. (See also *A-Stage* and *C-Stage.*)

Bag Molding.—A method of molding or bonding involving the application of fluid pressure, usually by means of air, steam, water, or vacuum, to a flexible cover which, sometimes in conjunction with the rigid die, completely encloses the material to be bonded.

Binder, *n.*—A component of an adhesive composition which is primarily responsible for the adhesive forces which hold two bodies together. (See also *Extender* and *Filler.*)

Blister, *n.*—An elevation of the surface of an adherend, somewhat resembling in shape a blister on the human skin; its boundaries may be indefinitely outlined and it may have burst and become flattened.

NOTE.—A blister may be caused by insufficient adhesive; inadequate curing time, temperature or pressure; or trapped air, water, or solvent vapor.

Blocking, *n.*—An undesired adhesion between touching layers of a material, such as occurs under moderate pressure during storage or use.

Bond, *n.*—The attachment at an interface between an adhesive and an adherend. (See also *Joint.*)

Bond, *v.*—To attach materials together by adhesives.

C-Stage, *n.*—The final stage in the reaction of a thermosetting resin in which the material is relatively insoluble and infusible. Thermosetting resins in a fully cured adhesive layer are in this stage.

Catalyst, *n.*—A substance which markedly speeds up the cure of an adhesive when added in minor quantity as compared to the amounts of the primary reactants. (See also *Hardener* and *Inhibitor.*)

Cement, n.—See Adhesive.

Cement, v.—See Bond, *v.*

Closed Assembly Time.—See Time, Assembly.

Cohesion, *n.*—The state in which the particles of a single substance are held to-

[3] 1949 Book of A.S.T.M. Standards, Part 6.

gether by primary or secondary valence forces. As used in the adhesive field, the state in which the particles of the adhesive (or the adherend) are held together.

Cold Flow.—See Creep.

Cold Pressing.—A bonding operation in which an assembly is subjected to pressure without the application of heat.

Cold-Setting Adhesive.—See Adhesive, Cold-Setting.

Colophony, n.—See Rosin.

Condensation, *n.*—A chemical reaction in which two or more molecules combine with the separation of water or some other simple substance. If a polymer is formed, the process is called polycondensation. (See also *Polymerization.*)

Conditioning Time.—See Time, Joint Conditioning.

Copolymer.—See Polymer.

Copolymerization.—See Polymerization.

Crazing, *n.*—Fine cracks which may extend in a network on or under the surface of or through a layer of adhesive.

Creep, *n.*—The dimensional change with time of a material under load, following the initial instantaneous elastic or rapid deformation. Creep at room temperature is sometimes called Cold Flow.

Cross Laminated.—See Laminated, Cross.

Cure, *v.*—To change the physical properties of an adhesive by chemical reaction, which may be condensation, polymerization, or vulcanization; usually accomplished by the action of heat and catalyst, alone or in combination, with or without pressure.

Curing Temperature.—See Temperature, Curing.

Curing Time.—See Time, Curing.

Delamination, *n.*—The separation of layers in a laminate because of failure of the adhesive, either in the adhesive itself or at the interface between the adhesive and the adherend, or because of cohesive failure of the adherend.

Double Spread.—See Spread.

Dry, *v.*—To change the physical state of an adhesive on an adherend by the loss of solvent constituents by evaporation or absorption, or both. (See also *Cure* and *Set.*)

Dry Strength.—See Strength, Dry.

Dry Tack.—See Tack, Dry.

Drying Temperature.—See Temperature, Drying.

Drying Time.—See Time, Drying.

Elastomer, *n.*—A material which at room temperature can be stretched repeatedly to at least twice its original length and, upon immediate release of the stress, will return with force to its approximate original length.

Extender, *n.*—A substance, generally having some adhesive action, added to an adhesive to reduce the amount of the primary binder required per unit area. (See also *Binder* and *Filler.*)

Filler, *n.*—A relatively nonadhesive substance added to an adhesive to improve its working properties, permanence, strength, or other qualities. (See also *Binder* and *Extender.*)

Gel, *n.*—A semisolid system consisting of a network of solid aggregates in which liquid is held.

Gelation, *n.*—Formation of a gel.

Glue, *n.*—Originally, a hard gelatin obtained from hides, tendons, cartilage, bones, etc., of animals. Also, an adhesive prepared from this substance by heating with water. Through general use the term is now synonymous with the term "adhesive." (See also *Adhesive, Mucilage, Paste,* and *Sizing.*)

Glue, v.—See Bond, *v.*

Gum, *n.*—Any of a class of colloidal substances, exuded by or prepared from plants, sticky when moist, composed of complex carbohydrates and organic acids, which are soluble or swell in water. (See also *Adhesive, Glue, Resin.*)

NOTE.—The term gum is sometimes used loosely to denote various materials that exhibit gummy characteristics under certain conditions, for example, gum balata, gum benzoin, and gum asphaltum. Gums are included by some in the category of natural resins.

Hardener, *n.*—A substance or mixture of substances added to an adhesive to promote or control the curing reaction by taking part in it. The term is also used to designate a substance added to control the degree of hardness of the cured film. (See also *Catalyst.*)

Hot-Setting Adhesive.—See Adhesive, Hot-Setting.

Inhibitor, *n.*—A substance which slows down chemical reaction. Inhibitors are sometimes used in certain types of adhesives to prolong storage or working life.

Intermediate Temperature Setting Adhesive.—See Adhesive, Intermediate Temperature Setting.

Joint, *n.*—The location at which two adherends are held together with a layer of adhesive. (See also *Bond, n.*)

Joint Aging Time.—See Time, Joint Conditioning.

Joint Conditioning Time.—See Time, Joint Conditioning.

Joint, Lap.—A joint made by placing one adherend partly over another and bonding together the overlapped portions. (See also *Joint, Scarf.*)

Joint, Scarf.—A joint made by cutting away similar angular segments of two adherends and bonding the adherends with the cut areas fitted together. (See also *Joint, Lap.*)

Joint, Starved.—A joint which has an insufficient amount of adhesive to produce a satisfactory bond.

NOTE.—This condition may result from too thin a spread to fill the gap between the adherends, excessive penetration of the adhesive into the adherend, too short an assembly time, or the use of excessive pressure.

Laminate, *n.*—A product made by bonding together two or more layers of material or materials. (See also *Laminated, Cross* and *Laminated, Parallel.*)

Laminate, *v.*—To unite layers of material with adhesive.

Lamination, *n.*—The process of preparing a laminate. Also, any layer in a laminate.

Laminated, Cross.—A laminate in which some of the layers of material are oriented at right angles to the remaining layers with respect to the grain or strongest direction in tension. (See also *Laminated, Parallel.*)

NOTE.—Balanced construction of the laminations about the center line of the thickness of the laminate is normally assumed.

Laminated, Parallel.—A laminate in which all the layers of material are oriented approximately parallel with respect to the grain or strongest direction in tension. (See also *Laminated, Cross.*)

Lap Joint.—See Joint, Lap.

Mechanical Adhesion.—See Adhesion, Mechanical, and Adhesion, Specific.

Monomer, *n.*—A relatively simple compound which can react to form a polymer. (See also *Polymer.*)

Mucilage, *n.*—An adhesive prepared from a gum and water. Also in a more general sense, a liquid adhesive which has a low order of bonding strength. (See also *Adhesive, Glue, Paste,* and *Sizing.*)

Novolak, *n.*—A phenolic-aldehydic resin which, unless a source of methylene groups is added, remains permanently thermoplastic. (See also *Resinoid* and *Thermoplastic.*)

Open Assembly Time.—See Time, Assembly.

Parallel Laminated.—See Laminated, Parallel.

Paste, *n.*—An adhesive composition having a characteristic plastic-type consistency, that is, a high order of yield value, such as that of a paste prepared by heating a mixture of starch and water and subsequently cooling the hydrolyzed product. (See also *Adhesive, Glue, Mucilage,* and *Sizing.*)

Polycondensation.—See Condensation.

Polymer, *n.*—A compound formed by the reaction of simple molecules having functional groups which permit their combination to proceed to high molecular weights under suitable conditions. Polymers may be formed by polymerization (addition polymer) or polycondensation (condensation polymer). When two or more monomers are involved, the product is called a copolymer.

Polymerization, *n.*—A chemical reaction in which the molecules of a monomer are linked together to form large molecules whose molecular weight is a multiple of that of the original substance. When two or more monomers are involved, the process is called copolymerization or heteropolymerization. (See also *Condensation.*)

Pot Life.—See Working Life.

Pressure-Sensitive Adhesive.—See Adhesive, Pressure-Sensitive.

Resin, *n.*—Any of a class of solid or semi-solid organic products of natural or synthetic origin, generally of high molecular weight with no definite melting point. (See also *Gum.*)

NOTE.—Resins are generally water-insoluble and have little or no tendency to crystallize. However, certain resins, such as some polyvinyl alcohols and polyacrylates, are readily dispersible in water, and others, such as polyamides and polyvinylidene chloride, are readily crystallized.

Resinoid, *n.*—Any of the class of thermosetting synthetic resins, either in their initial temporarily fusible state or in their final infusible state. (See also *Novolak* and *Thermosetting.*)

Retarder.—See Inhibitor.

Room Temperature Setting Adhesive.—See Adhesive, Room Temperature Setting.

Rosin, *n.*—A resin obtained as a residue in the distillation of crude turpentine from the sap of the pine tree (gum rosin) or from an extract of the stumps and other parts of the tree (wood rosin).

Scarf Joint.—See Joint, Scarf.

Self-Curing, adj.—See Self-Vulcanizing.

Self-Vulcanizing, *adj.*—Pertaining to an adhesive which undergoes vulcanization without the application of heat.

Separate Application Adhesive.—See Adhesive, Separate Application.

Set, *v.*—To convert an adhesive into a fixed or hardened state by chemical or physical action, such as condensation, polymerization, oxidation, vulcanization, gelation, hydration, or evaporation of volatile constituents. (See also *Cure* and *Dry.*)

Setting Temperature.—See Temperature, Setting.

Setting Time.—See Time, Setting.

Shelf Life.—See Storage Life.

Single Spread.—See Spread.

Size, n.—See Sizing.

Sizing, *n.*—The process of applying a material on a surface in order to fill pores and thus reduce the absorption of the subsequently applied adhesive or coating or to otherwise modify the surface properties of the substrate to improve the adhesion. Also, the material used for this purpose. The latter is sometimes called Size.

Specific Adhesion.—See Adhesion, Specific and Adhesion, Mechanical.

Spread, *n.*—The quantity of adhesive per unit joint area applied to an adherend. It is preferably expressed in pounds of liquid or solid adhesive per thousand square feet of joint area.

1. *Single Spread* refers to application of adhesive to only one adherend of a joint.
2. *Double Spread* refers to application of adhesive to both adherends of a joint.

Storage Life.—The period of time during which a packaged adhesive can be stored under specified temperature conditions and remain suitable for use. Sometimes called Shelf Life. (See also *Working Life.*)

Starved Joint.—See Joint, Starved.

Strength, Dry.—The strength of an adhesive joint determined immediately after drying under specified conditions or after a period of conditioning in the standard laboratory atmosphere. (See also *Strength, Wet.*)

Strength, Wet.—The strength of an adhesive joint determined immediately after removal from a liquid in which it has been immersed under specified conditions of time, temperature, and pressure.

NOTE.—The term is commonly used alone to designate strength after immersion in water. In the latex adhesives the term is also used to describe the joint strength when the adherends are brought together with the adhesive still in the wet state.

Substrate, *n.*—A material upon the surface of which an adhesive-containing substance is spread for any purpose, such as bonding or coating. A broader term than adherend. (See also *Adherend.*)

Tack, *n.*—Stickiness of an adhesive.

NOTE.—This property is measured as the pull resistance to effect division without failure or deformation occurring in the adherend surroundings or at the interface while the adhesive still exhibits viscous or plastic flow. The measured value may vary with time temperature, film thickness, etc.

Tack, Dry.—The property of certain adhesives, particularly nonvulcanizing rub-

ber adhesives, to adhere on contact to themselves at a stage in the evaporation of volatile constituents, even though they seem dry to the touch. Sometimes called Aggressive Tack.

Tack Range.—The period of time in which an adhesive will remain in the tacky-dry condition after application to an adherend, under specified conditions of temperature and humidity.

Tacky-Dry, adj.—Pertaining to the condition of an adhesive when the volatile constituents have evaporated or been absorbed sufficiently to leave it in a desired tacky state.

Temperature, Curing.—The temperature to which an adhesive or an assembly is subjected to cure the adhesive. (See also *Temperature, Drying* and *Temperature, Setting.*)

NOTE.—The temperature attained by the adhesive in the process of curing it (adhesive curing temperature) may differ from the temperature of the atmosphere surrounding the assembly (assembly curing temperature).

Temperature, Drying.—The temperature to which an adhesive on an adherend or in an assembly or the assembly itself is subjected to dry the adhesive. (See also *Temperature, Curing* and *Temperature, Setting.*)

NOTE.—The temperature attained by the adhesive in the process of drying it (adhesive drying temperature) may differ from the temperature of the atmosphere surrounding the assembly (assembly drying temperature).

Temperature, Setting.—The temperature to which an adhesive or an assembly is subjected to set the adhesive. (See also *Temperature, Curing* and *Temperature, Drying.*)

NOTE.—The temperature attained by the adhesive in the process of setting it (adhesive setting temperature) may differ from the temperature of the atmosphere surrounding the assembly (assembly setting temperature).

Thermoplastic, *adj.*—Capable of being repeatedly softened by heat and hardened by cooling.

Thermoplastic, *n.*—A material which will repeatedly soften when heated and harden when cooled.

Thermoset, *adj.*—Pertaining to the state of a resin in which it is relatively infusible.

Thermoset, *n.*—A material which will undergo or has undergone a chemical reaction by the action of heat, catalysts, ultraviolet light, etc., leading to a relatively infusible state.

Thermosetting, *adj.*—Having the property of undergoing a chemical reaction by the action of heat, catalysts, ultraviolet light, etc., leading to a relatively infusible state.

Time, Assembly.—The time interval between the spreading of the adhesive on the adherend and the application of pressure or heat, or both, to the assembly.

NOTE.—For assemblies involving multiple layers or parts, the assembly time begins with the spreading of the adhesive on the first adherend.

1. *Open Assembly Time* is the time interval between the spreading of the adhesive on the adherend and the completion of assembly of the parts for bonding.
2. *Closed Assembly Time* is the time interval between completion of assembly of the parts for bonding and the application of pressure or heat, or both, to the assembly.

Time, Curing.—The period of time during which an assembly is subjected to heat or pressure, or both, to cure the adhesive. (See also *Time, Drying, Time; Joint Conditioning;* and *Time, Setting.*)

NOTE.—Further cure may take place after removal of the assembly from the conditions of heat or pressure, or both; see Time, Joint Conditioning.

Time, Drying.—The period of time during which an adhesive on an adherend or an assembly is allowed to dry with or without the application of heat or pressure, or both. (See also *Time, Curing; Time, Joint Conditioning;* and *Time, Setting.*)

Time, Joint Conditioning.—The time interval between the removal of the joint

from the conditions of heat or pressure, or both, used to accomplish bonding and the attainment of approximately maximum bond strength. Sometimes called Joint Aging Time.

Time, Setting.—The period of time during which an assembly is subjected to heat or pressure, or both, to set the adhesive. (See also *Time, Curing; Time, Joint Conditioning;* and, *Time, Drying.*)

Vulcanization, *n.*—A chemical reaction in which the physical properties of a rubber are changed in the direction of decreased plastic flow, less surface tackiness, and increased tensile strength by reacting it with sulfur or other suitable agents. (See also *Self-Vulcanizing.*)

Vulcanize, *v.*—To subject to vulcanization.

Warm-Setting Adhesive.—See Adhesive, Warm-Setting.

Wet Strength.—See Strength, Wet.

Wood Failure.—The rupturing of wood fibers in strength tests on bonded specimens, usually expressed as the percentage of the total area involved which shows such failure.

Wood Veneer.—A thin sheet of wood, generally within the thickness range of 0.01 to 0.25 in., to be used in a laminate.

Working Life.—The period of time during which an adhesive, after mixing with catalyst, solvent, or other compounding ingredients, remains suitable for use. (See also *Storage Life.*)

Tentative Method of Test for

IMPACT STRENGTH OF ADHESIVES[1]

A.S.T.M. Designation: D 950 – 47 T

ISSUED, 1947.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to insure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding which are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, October 31, 1947.

Scope

1. This method of test is intended for determining the comparative impact strength of adhesives in shear, when tested on standard specimens under specified conditions of preparation, conditioning, and testing.

(*a*) *Testing Machine.*—A pendulum type impact machine with a head velocity of 11 ft. per sec., comprising essentially the following:

(*1*) An impact head equipped with a flat striking face slightly wider than the test specimen, aligned to strike the specimen full-face.

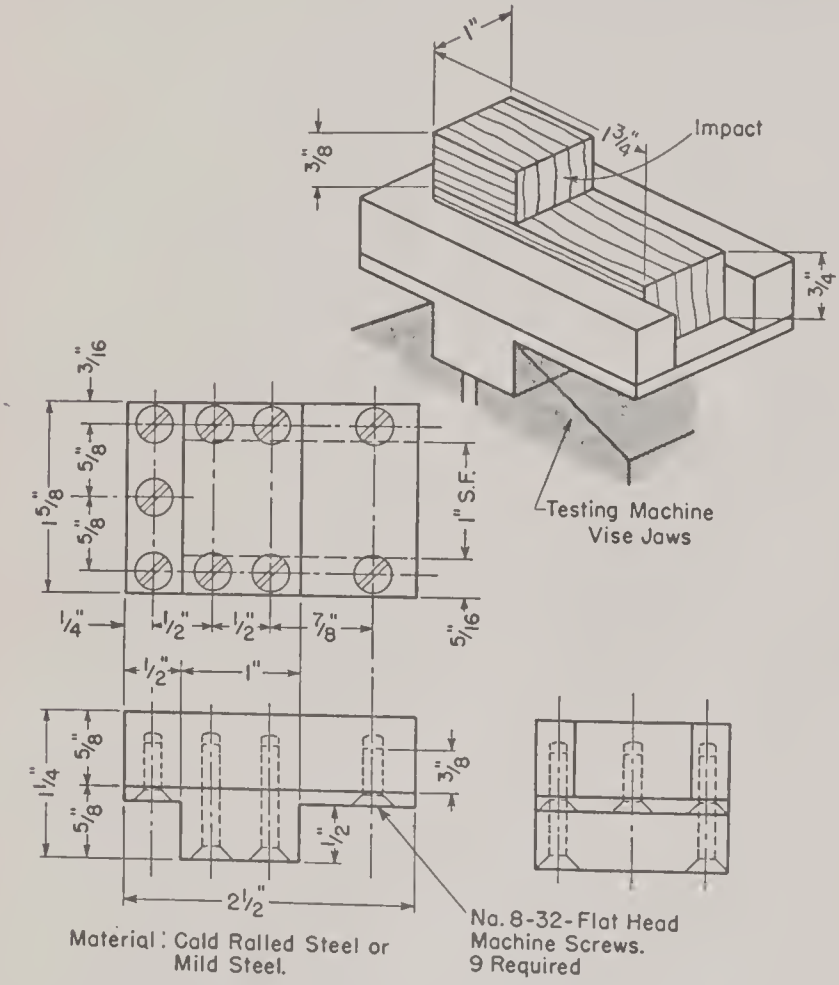

FIG 1.—Adapter Jig for Impact Machines.

Impact Strength

2. Impact strength is the minimum force that, when applied as shock to a standard specimen, will cause failure of the specimen in a single blow. Impact strength is expressed in foot-pounds per square inch.

Apparatus

3 The apparatus shall consist of the following:

(*2*) A jig to hold the test specimen as shown in Fig. 1. The jig shall be square so that the specimen will fit snugly and butt squarely against the retaining end of the jig. The jig shall be so located that the specimen will be struck at the point of maximum head velocity.

(*3*) A vise to hold the jig rigid and immobile under the impact loads.

(*b*) The specimen shall be placed in the jig in the vise of the impact machine so that the specimen butts squarely against the retaining end of the jig. The impact head of the machine shall be rested gently against the specimen and the jig adjusted so that the head fits squarely against the impact face of the specimen.

(*c*) The impact head shall then be raised to a predetermined height and the safety catch released. The impact load absorbed by the specimen may then be read directly.

(*d*) The following information shall be recorded:

(*1*) Record foot-pounds of energy absorbed in producing failure of the specimen.

(*2*) Record bonded area of specimen.

(*3*) In case of metal-to-metal adhesives, record the percentages of cohesion, adhesion, and contact failures (Note). This will be based on visual inspection.

(*4*) In case of wood-to-wood adhesives, record the percentages of wood, glue, and contact failures. This will be based on visual inspection.

NOTE.—Cohesion failure may be obtained by observing how much of the failure has occurred in the adhesive itself. That is, if the cement has adhered to the metal test pieces and no voids are visible, it represents a 100 per cent cohesion failure. Adhesion failure refers to the lack of adhering to metals being fastened. Contact failure refers to lack of glue lines being in contact due to uneven surfaces, poor pressure distribution, etc.

Calculations

9. (*a*) Impact strength of the specimen shall be calculated as the energy absorbed in producing failure of the specimen divided by the bonded area of the specimen, and shall be expressed in foot-pounds per square inch. Values shall be reported to the nearest tenth of a foot-pound.

(*b*) For each series of tests, the arithmetic mean of values obtained shall be calculated and reported as the "average value."

Report

10. The report shall include the following:

(*1*) Complete identification of the adhesive tested, including type, source, manufacturer's code numbers, form, etc.,

(*2*) Method of preparing test specimens, dimensions of specimens, and materials bonded,

(*3*) Conditioning procedure used,

(*4*) Atmosphere conditions in test room,

(*5*) Number of specimens tested,

(*6*) Maximum, minimum, and average value of impact strength, with an average value of the percentages of wood, glue, and contact failures for the wood specimens, or cohesion, adhesion, and contact failures for the metal specimens.

Tentative Method of Test for

STRENGTH PROPERTIES OF ADHESIVES IN SHEAR BY TENSION LOADING (METAL-TO-METAL)[1]

A.S.T.M. Designation: D 1002 – 49 T

ISSUED, 1949.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to ensure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding that are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive, including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure, and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Administrative Committee on Standards, May 2, 1949.

Scope

1. This method is intended for determining the comparative shear strengths of adhesives for bonding metals when tested on a standard specimen and under specified conditions of preparation and testing.

Apparatus

2. The testing machine shall conform to the requirements of the Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4).[3] The testing machine shall be so selected that the breaking load of the specimens falls between 15 and 85 per cent of the full scale capacity. The machine shall be capable of maintaining a rate of loading of 600 to 700 lb. per min., or if rate is dependent on crosshead motion, the machine should be set to approach this rate of loading. It shall be provided with a suitable pair of self-aligning grips to hold the specimen. The jaws of these grips shall engage the outer 3 in. of each end of the test specimen firmly (Note). The grips and attachments shall be so constructed that they will move into alignment with the test specimen as soon as the load is applied, so that the long axis of the test specimen will coincide with the direction of the applied pull through the center line of the grip assembly.

NOTE.—If certain grips will hold specimens sufficiently firm, the length in the grips may be reduced to 2 in. and the specimens shortened by 1 in. from each end. The space between grips must be 3 in. in any case.

Test Specimens

3. (*a*) Test specimens shall conform to the form and dimensions shown in Fig. 1. These shall be cut from test joints prepared as prescribed in Section 4. The recommended thickness of the sheets is 0.064 ± 0.005 in.

[3] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

NOTE.—A variation in thickness of the metal will likely influence the test values. For this reason, in comparative or specification tests, the thickness should be 0.064 ± 0.005 in. For development tests this could be different but should be constant.

(*b*) The following grades of metal are recommended for the test specimens:

Metal	A.S.T.M. Designation[a]
Brass	B 36, alloy 8
Copper	B 152, type A
Aluminum	B 209, alloy CG21, T3 temper
Steel	A 109, grade 2
Corrosion-resisting steel	A 167, grade 2

[a] These designations refer to the following specifications of the American Society for Testing Materials:

Tentative Specifications for Brass Plate, Sheet and Strip (A.S.T.M. Designation: B 36),[4]
Tentative Specifications for Copper Sheet, Strip and Plate (A.S.T.M. Designation: B 152),[4]
Tentative Specifications for Aluminum and Aluminum-Alloy Sheet and Plate (A.S.T.M. Designation: B 209),[4]
Tentative Specifications for Cold-Rolled Strip Steel (A.S.T.M. Designation: A 109),[5] and
Standard Specifications for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet and Strip (A.S.T.M. Designation: A 167).[5]

(*c*) At least 20 specimens shall be tested, representing at least four different joints.

Preparation of Test Joints

4. Test specimens shall be made up in multiples of at least 5 specimens and then cut into individual test specimens. Sheets of the metals prescribed in Section 3(*a*) and (*b*) shall be cut to suitable size. A size of 5 by 6 in. has been found convenient. The sheets shall be cleaned and dried carefully according to the procedure prescribed by the manufacturer of the adhesive and assembled in pairs. The adhesive shall be prepared and applied, according to the recommendations of the manufacturer of the adhesive, to an area 1.25 in. in length across the end of one or both metal sheets. The sheets shall then be assembled and held rigidly so that the length of overlap shall be 1.00 ± 0.05 in., and the adhesive allowed to cure as prescribed by the manufacturer of the adhesive.

[4] 1949 Book of A.S.T.M. Standards, Part 2.
[5] 1949 Book of A.S.T.M. Standards, Part 1.

Preparation of Test Specimens

5. Test specimens, as shown in Fig. 1, shall be cut from the joints. This cutting operation shall be done so as to avoid overheating or mechanical damage to the joints (Note). At least 0.25 in. of the joint shall be discarded from each edge of each panel. The width of the specimen and the length of the overlap shall be measured to the nearest 0.05 in. to determine the shear area.

NOTE.—A fine tooth, typesetter's circular saw has been found suitable for such purposes.

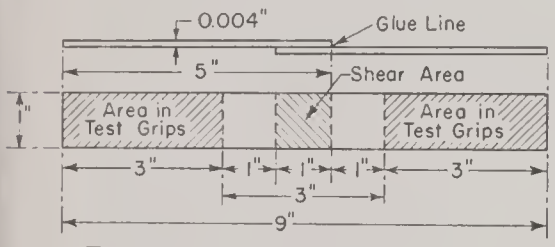

FIG. 1.—Form and Dimensions of Test Specimen.

Procedure

6. (*a*) Specimens, prepared as prescribed in Section 5, shall be tested as soon after preparation as possible. The manufacturer of the adhesive may, however, prescribe a definite period of conditioning under specific conditions before testing.

(*b*) Specimens shall be placed in the grips of the testing machine so that the outer 3 in. of each end are in contact with the jaws (Note, Section 2) and so that the long axis of the test specimen shall coincide with the direction of applied pull through the center line of the grip assembly. The loading shall be applied immediately to the specimen at the rate of 600 to 700 lb. per min. or the crosshead speed of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.050 in. per min. (1.27 mm. per min.) when the machine is running idle. The load shall be continued to failure.

Calculations

7. The load at failure and the nature and amount of this failure (cohesion in adhesive or metal, or adhesion) shall be recorded for each specimen. All failing loads shall be expressed in pounds per square inch of shear area, calculated to the nearest 0.01 sq. in.

Report

8. The report shall include the following:

(*1*) Complete identification of the adhesive tested including type, source, manufacturers' code numbers, form, etc.,

(*2*) Complete identification of the metal used, its thickness, and the method of cleaning and preparing its surfaces prior to bonding,

(*3*) Application and bonding conditions used in preparing the specimens,

(*4*) Conditioning procedure used for specimens prior to testing,

(*5*) Number of specimens tested,

(*6*) Number of joints represented,

(*7*) Maximum, minimum, and average values for the failing load. According to agreement between the purchaser and the manufacture of the adhesive, all individual test values, the standard deviation, or both may also be required.

(*8*) The nature of the failure including the average estimated percentages of failure in the cohesion of the adhesive, cohesion of the metal, and adhesion to the metal.

Tentative Method of Test for

CLEAVAGE STRENGTH OF METAL-TO-METAL ADHESIVES[1]

A.S.T.M. Designation: D 1062 – 49 T

ISSUED, 1949.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon by the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to ensure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding that are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive, including the rate of spread or thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure, and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-14 on Adhesives.

[2] Accepted by the Society at annual meeting, June, 1949.

Scope

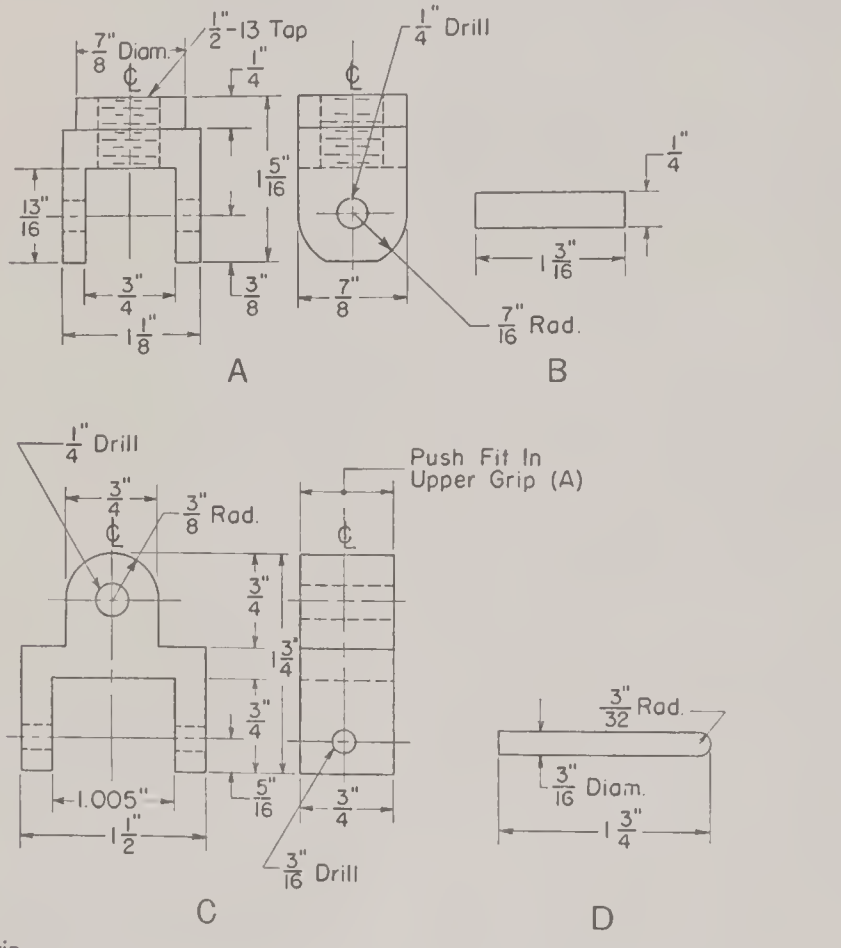
1. This method is intended for determining the comparative cleavage properties of adhesives when tested on standard shape metal specimens under specified conditions of preparation and testing. It may be used also to compare adhesives used with other metallic materials having any specified surface treatment.

Description of Terms

2. (*a*) *Cleavage Strength* is the tensile load in terms of pounds per inch of width required to cause separation of a test specimen 1 in. in length as described in this method.

(*b*) *Cohesion Failure* is that failure which occurs in the adhesive itself. That is, if the cement has adhered to the metal test pieces and no voids are visible, 100 per cent cohesive failure is shown.

(*c*) *Adhesion Failure* refers to the lack of adherence to metals being fastened.



A—Upper grip.
B—Pin connecting upper and lower grips.
C—Lower grip.
D—Pin for attaching grip to specimen.

FIG. 1.—Details of Test Grips.

(*d*) *Contact Failure* refers to the lack of glue lines being in contact due to uneven surfaces, poor pressure distribution, etc.

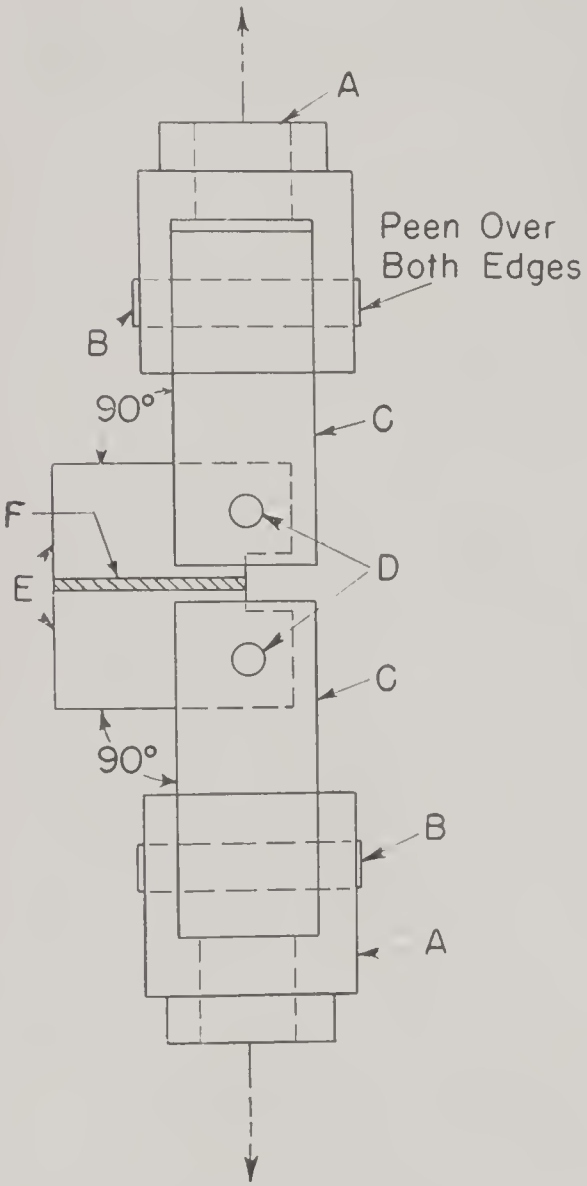
Apparatus

3. The testing machine shall be capable of maintaining the rate of loading specified in Section 7 (*b*), and shall consist essentially of the following:

(*a*) *Fixed Member.*—A fixed or es-

sentially stationary member, carrying one grip.

(*b*) *Movable Member.*—A movable member, carrying a second grip.



A—Upper grip.
B—Pin connecting upper and lower grips.
C—Lower grip.
D—Pin for attaching grip to specimen.
E—Metal pieces.
F—Glue line.

FIG. 2.—Assembly of Grips and Test Specimen for Cleavage Strength Test.

(*c*) *Grips.*—Grips for holding a test specimen between the fixed member and the movable member. The grips shall be of the self-aligning type; that is, they shall be attached to the fixed and movable member, respectively, in such a way that they will move into alignment as soon as any load is applied, so that the direction of pull is at right angles to the point of adhesion. Recommended grips are shown in Figs. 1 and 2.

Test Specimens

4. (*a*) The test specimens shall consist of metal pieces, conforming to the dimensions and conditions shown in Fig. 3, and glued together as described in Section 5 with the adhesive to be tested. Various metallic materials and surface treatments may be specified to simulate surface conditions. The following grades of metal are recommended for the test specimens, as being representative of a wide range of metallic materials:

Metal	A.S.T.M. Designation[a]
Brass	B 16
Copper	B 133, type A
Aluminum	B 211, alloy CG21
Steel	A 108, grade 1020
Phosphor bronze	B 139, grade B2

[a] These designations refer to the following specifications of the American Society for Testing Materials:
Standard Specifications for Free-Cutting Brass Rod and Bar for Use in Screw Machines (A.S.T.M. Designation: B 16),[3]
Tentative Specifications for Copper Rods, Bars, and Shapes (A.S.T.M. Designation: B 133),[3]
Tentative Specifications for Aluminum and Aluminum-Alloy Bars, Rods, and Wire (A.S.T.M. Designation: B 211),[3]
Tentative Specifications for Cold-Finished Carbon-Steel Bars and Shafting (A.S.T.M. Designation: A 108),[4]
Tentative Specifications for Phosphor Bronze Rods, Bars, and Shapes (A.S.T.M. Designation: B 139).[3]

(*b*) The metal pieces may be re-used after testing, provided the adhesive is completely removed from the adhering surfaces and the surfaces are reconditioned.

(*c*) Unless otherwise agreed upon by the purchaser and the manufacturer, at least ten specimens shall be tested for each adhesive, but in no case shall the number of specimens be less than five.

[3] 1949 Book of A.S.T.M. Standards, Part 2.
[4] 1949 Book of A.S.T.M. Standards, Part 1.

Gluing

5. (*a*) Preparation of the areas that are to be cemented and the gluing operations shall be done in accordance with the procedure outlined by the manufacturer of the adhesive.

(*b*) It is important that all flash be carefully removed from the edges of the specimen.

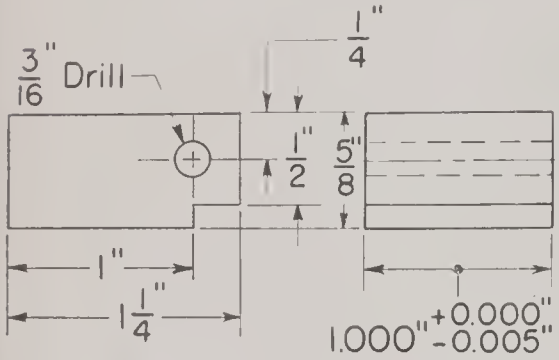


FIG. 3.—Metal Piece for Use in Test Specimen.

NOTE.—The 1-in. square surface to be glued shall be ground flat and parallel with the opposite surface.

Conditioning

6. Unless special conditioning procedures are agree upon by the purchaser and the manufacturer the adhesive is ready for test when it has been applied in accordance with Section 5.

Procedure

7. (*a*) The specimen shall be placed in the grips of the testing machine, taking care to align the specimen as indicated in Fig. 2.

(*b*) Tensile load shall be applied at the rate of 600 to 700 lb. per min., or the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. per min. (1.27 mm. per min.) when the machine is running idle.

(*c*) Record the maximum load in pounds carried by the specimen at failure. Record the percentages of cohesion, adhesion, and contact failures.

Calculation

8. Cleavage strength shall be the breaking load and shall be expressed in pounds per inch. If possible, the results shall be reported to three significant figures.

Report

9. The report shall include the following:

(*1*) Complete identification of the adhesive tested, including type, source, manufacturer's code numbers, form, etc.,

(*2*) Method of preparing test specimens,

(*3*) Conditioning procedure used,

(*4*) Conditions of testing room,

(*5*) Number of specimens tested,

(*6*) Rate of loading,

(*7*) Maximum, minimum, and average value of cleavage strength. Optionally, by agreement between the purchaser and the manufacture of the adhesive, all individual test results, the standard deviation, or both may also be required in the report.

(*8*) Average value of the percentage of cohesion failure.

Standard Methods of Test for
VISCOSITY AND TOTAL SOLIDS CONTENT OF RUBBER CEMENTS[1]

A.S.T.M. Designation: D 553 - 42

ADOPTED, 1942.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 553; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods of test cover procedures for determining the viscosity and total solids content of rubber cements containing organic solvents as differentiated from latex cements or dispersions of rubber in water.

TOTAL SOLIDS

Procedure

2. Approximately 10 g. of the sample shall be poured into a low-form weighing bottle, covered, and weighed. After removing the cover, heat shall be applied at 70 C. until the sample reaches constant weight. The sample shall then be cooled in a desiccator and weighed.

Calculations

3. The percentage of total solids shall be calculated as follows:

$$\text{Total solids, per cent} = \frac{\text{wt. of residue}}{\text{wt. of sample}} \times 100$$

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials.

[2] Prior to adoption as standard, these methods were published as tentative from 1939 to 1942.

VISCOSITY

Viscosity Tests

4. The following alternate procedures for determining viscosity are included:

Funnel Method.—This method gives closely duplicable results but is limited in use to those cements having viscosities which permit sufficiently rapid flow through the funnel to avoid excessive loss of solvent.

Falling Cylinder Method.—This method is adapted to rubber cements having a wider range of viscosities and offers some advantages in control testing due to ease of manipulation.

Funnel Method

Apparatus

5. The funnel type viscosimeter shall be constructed as shown in Fig. 1.

Procedure

6. The tests shall be made at 77 ± 3.6 F. (25 ± 2 C.). Both the sample of cement to be tested and the apparatus

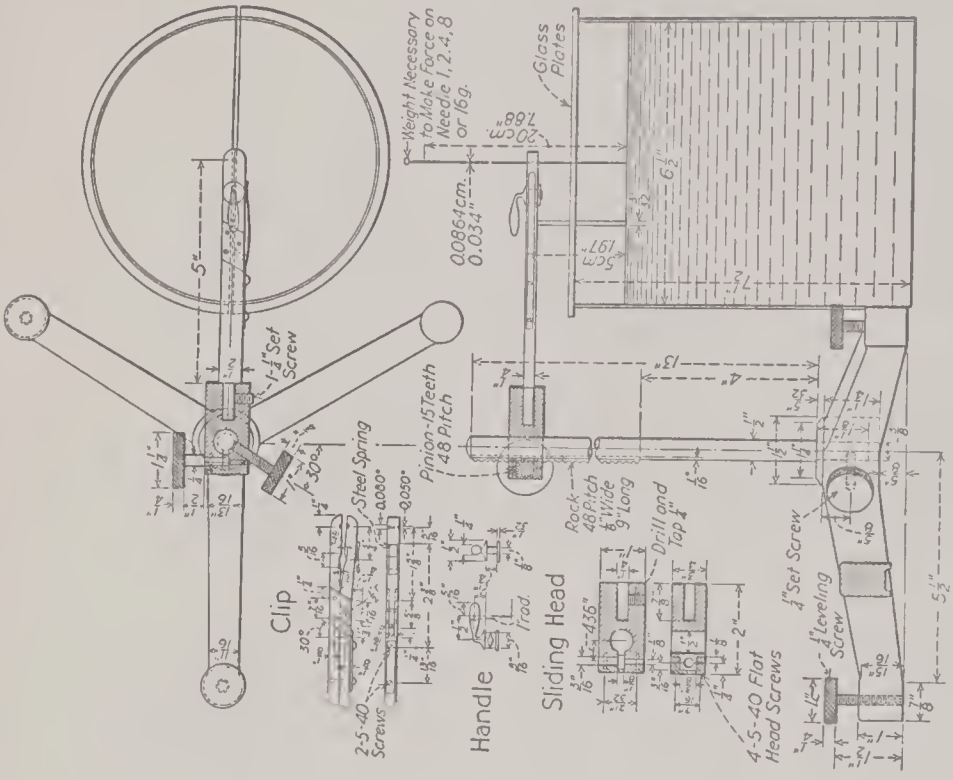


FIG. 2.—Falling Cylinder Viscosimeter.

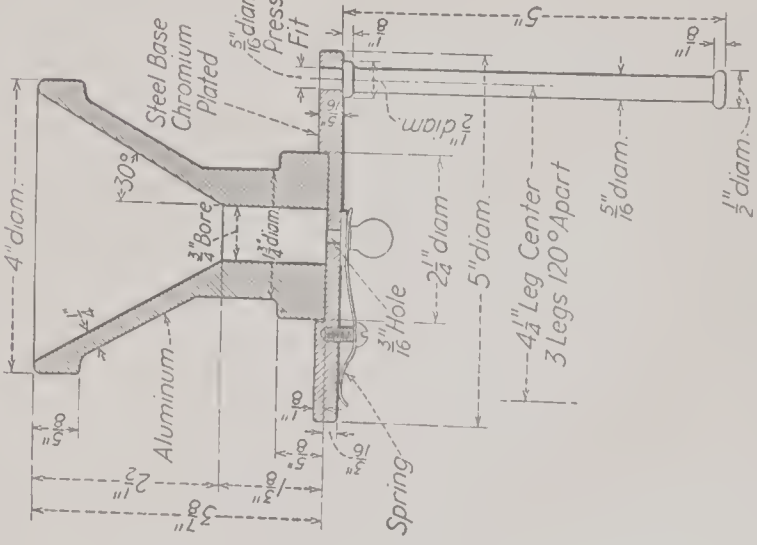


FIG. 1.—Funnel Type Viscosimeter.

shall be adjusted to this temperature before starting the test. The viscosimeter shall be adjusted so that the orifice is perpendicular to a smooth horizontal surface. With the orifice closed the viscosimeter shall be charged with 125 ml. of cement (Note). The orifice shall then be opened and the cement allowed to flow. The time of flow shall be measured by means of a stop watch.

NOTE.—In charging the viscosimeter, care must be exercised that no air is trapped in the straight portion below the funnel. The best precaution against trapping air is to pour the sample slowly into the side of the funnel until the straight portion is filled.

Report

7. The viscosity shall be reported as the number of seconds required for the sample of cement to discharge until the liquid level is just at the bottom of the conical section of the funnel.

Falling Cylinder Method

Apparatus

8. The falling cylinder viscosimeter shall be constructed as shown in Fig. 2. Each cylinder shall be marked with two circumferential lines, one line 5.00 cm. from the lower end, and the other line 15.00 cm. from the first line. The cylinders shall conform to the following requirements:

Cylinder	Diameter, in.	Weight, g.
No. 1	0.034	1.047
No. 2	0.034	2.047
No. 3	0.034	4.047
No. 4	0.034	8.047
No. 5	0.034	16.047
No. D	0.032	0.306

Procedure

9. The temperature of the sample shall be adjusted to 77 ± 3.6 F. (25 ± 2 C.). After attaching the clip to the ring stand, a 1-gal. can of cement shall be placed directly under the clip. The clip shall be adjusted to such a height that the lower end of the adjustment needle just touches the surface of the cement. In this position the first mark on the cylinder will be flush with the top of the clip. The surface of the cement shall be skimmed, the cylinder immediately positioned, and the control on the cylinder released while at the same time a stop watch shall be started to record the time. The needle shall be kept falling freely through the clip by moving the container as required. The test is completed when the second mark reaches the clip, corresponding to a drop of 15 cm. To remove the needle after a test, release the jaws of the clip by means of the trigger. This prevents cement running into the orifice.

Report

10. The viscosity shall be reported as the number of seconds required for the specified needle to fall through the orifice in the clip from one marker to the other.

Standard Methods of

SAMPLING AND TESTING LATICES OF NATURAL RUBBER AND SYNTHETIC RUBBERS[1]

A.S.T.M. Designation: D 640 – 44

ADOPTED, 1944.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 640; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods are intended for use, as required, in sampling and measuring variability in composition of normal and concentrated rubber latex and synthetic rubber latices.

NOTE.—Other determinations in addition to those described in these methods are frequently used in testing rubber latex but have not been included, pending further development.

Sampling Latex in Drums

2. (*a*) In case the sampling operation takes place immediately after the drum is filled, no further mixing is required, but if the drum has stood, the top shall be removed and the contents stirred with a high-speed stirrer for 10 min.

(*b*) If closed-head drums are used, a procedure of rolling and up-ending the drums shall be employed; rolling alone is not sufficient. If there is a free air space in the drum, satisfactory mixing can be accomplished within a short time by this means. In the case of full drums all of the latex in the closed-head drum shall be transferred to a larger vessel and mixed thoroughly before taking the sample.

(*c*) A 1-liter (32-oz.) dry, open bottle shall be attached to a 120-cm. (4-ft.) length of 0.625-cm. (0.25-in.) steel rod. The bottle thus attached to the rod shall be introduced into the drum and run down through the entire body of latex. The bottle shall then be withdrawn, and the contents emptied back into the drum. This initial filling minimizes the possibility of error from moisture that may be in the bottle. The bottle shall then be filled again in the same manner. It will be found advantageous to leave a small air space in the top of the bottle after the second filling in order to facilitate mixing before weighing out samples.

Sampling Latex in Tank Cars

3. (*a*) In case the tank car has been freshly filled, no further mixing will be necessary. If the car has stood, the latex shall be mixed by means of a jet of air from a 1.25-cm. (0.5-in.) pipe inserted through the dome cover of the car and moved continuously throughout the body of the latex. In the case of

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials.

[2] Prior to adoption as standard, these methods were published as tentative from 1941 to 1944, being revised in 1944.

normal latex, this operation shall be continued for 15 min., and in the case of creamed or centrifuged latex it shall be continued for about 45 min.

(*b*) When the contents of the car have been thoroughly mixed, a 1-liter (32-oz.) narrow-mouth sample bottle attached to a 300-cm. (10-ft.) length of steel rod shall be introduced into the car. The bottle shall be withdrawn and the contents emptied back into the car. This initial filling minimizes the possibility of error from moisture that may be in the bottle. Next, the bottle shall be forced quickly down through the body of the latex, and raised and lowered rapidly through the entire depth of the tank car several times. On account of the narrow mouth, there will be time to do this during the period of filling of the bottle. The bottle shall be withdrawn when it is completely filled. Just enough latex shall be poured out to leave a small air space in the top, and the bottle shall then be stoppered tightly.

Total Solids

4. (*a*) Weigh 2.5 ± 0.5 g. of the latex to be tested into a tared, covered, flat-bottom glass weighing dish. The latex should be uniformly distributed over the bottom of the dish, during drying, over an area of approximately 32 sq. cm. (5 sq. in.). With the dish uncovered, dry the specimen in air for 16 hr. at 70 C. Cool the dried film to room temperature and weigh.

(*b*) Calculate the percentage of total solids as follows:

$$\text{Total solids, per cent} = \frac{\text{wt. of dried film}}{\text{wt. of latex sample}} \times 100$$

Dry Rubber Content

5. (*a*) Weigh a representative sample of not less than 20 g. of normal latex or 10 g. of concentrated latex into a porcelain evaporating dish, and add distilled water until the total solids content is approximately 25 per cent. Add acetic acid (2.0 per cent), while stirring constantly, until the latex appears to be coagulated and more acid produces no effect. Place the dish on a steam bath for 30 min., then pour off the serum and replace it with distilled water. Remove the coagulum and pass it between the tightly closed rolls of a laundry wringer or similar device, wash it again with distilled water, and wring out. Repeat this process five times. Dry the resulting crepe to constant weight at 70 C.

(*b*) Calculate the dry rubber content as follows:

$$\text{Dry rubber content, per cent} = \frac{\text{wt. of dry coagulum}}{\text{wt. of sample}} \times 100$$

Preparation of Sample for Chemical Analysis

6. Spread the latex to be dried on a flat glass plate. Convenient amounts to use are 1 ml. of normal latex per 6.45 sq. cm. (1 sq. in.) of surface or 0.5 ml. of concentrated latex per 6.45 sq. cm. Place the plate in a current of warm air at approximately 90 F., and allow the latex to dry slowly to a transparent film.

NOTE.—This method of preparing a dried film of latex rubber is specified in order to obtain in a uniform manner a material that can be directly subjected to the procedures for determination of manganese, copper, and acetone extract as described in the Tentative Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[3]

Report

7. The report shall include the following:

(*1*) Identification of sample and statement of the method of sampling used, and

(*2*) Results of all determinations made.

[3] 1949 Book of A.S.T.M. Standards, Part 6.

Tentative Methods of

TESTING RUBBER ADHESIVES[1]

A.S.T.M. Designation: D 816 – 46 T

ISSUED, 1944; REVISED, 1946.[2]

These Tentative Methods have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. These methods are intended for use in testing the properties of adhesives which may be applied in plastic or fluid form and which are manufactured from natural rubber, reclaimed rubber, synthetic elastomers, or combinations of these materials. They are not all to be considered as applicable to a particular type of adhesive nor do they necessarily include every test which may be applicable to a particular type. They do, however, provide procedures in standard form for evaluating the more important properties of the usual adhesives ordinarily classed as rubber cements.

Classes of Tests

2. The tests described in these methods may be classified in two groups, the first including those procedures in which the adhesive is applied to specimens of materials to be bonded after which the quality of the bond is evaluated, and the second including those procedures applicable to the adhesive itself without consideration of the bonding properties. The tests in class 1 are those for adhesion strength, bonding range, softening point, and cold flow. Those in class 2 comprise determinations of viscosity, stability, cold brittleness, weight per gallon, and plastic deformation (for heavy doughs or putties).

Materials for Bonded Specimens

3. The following materials shall be used as specified for the preparation of specimens bonded with the test cement for tests of class 1 and shall be reported with the result of the test:

Aluminum sheet, cladded material, gage 0.064 in.

Standard rubber test slabs.[a]

Cotton duck (30.31 oz. per sq. yd., medium texture, A.S.T.M. Specifications D 230).[b]

Coated fabrics of which the fabric strength and the adhesion of coating to fabric exceed the strength of the adhesive bond.

Rolled sheet or machined steel, S.A.E. No. 1020, sand blasted or sanded with 240 grit abrasive.[c]

Special materials such as leather, cork, felt, etc.

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials.

[2] Revision accepted by the Society at annual meeting, June, 1946.

[a] See Section 4 of the Standard Methods of Sample Preparation for Physical Testing of Rubber Products (A.S.T.M. Designation: D 15) [3]

[b] Standard Specifications for Numbered Cotton Duck and Army Duck (A.S.T.M. Designation: D 230).[4]

[c] 1949 S.A.E. Handbook, p. 289.

[3] 1949 Book of A.S.T.M. Standards, Part 6.

[4] 1949 Book of A.S.T.M. Standards, Part 5.

NOTE.—In reporting tests using aluminum sheet, the alloy and type of cladding shall be stated. Care shall also be taken when rubber test slabs are used for bonded specimens to report the compound actually employed. In the case of coated fabrics, the exact nature of the coating shall be stated. Any special materials shall be completely identified and described in the report.

Sampling

4. Before sampling, the cement to be tested shall be thoroughly agitated to uniform consistency throughout, after which a sample shall be taken of sufficient quantity for performance of the tests required. The sample shall be kept in a tightly closed container to prevent evaporation and shall be agitated or stirred to uniform consistency immediately before test or use in preparation of test specimens.

Test Conditions

5. The tests of adhesives shall be conducted at a temperature of 77 ± 5 F. and relative humidity of 50 ± 5 per cent. All material and equipment shall be held at these conditions prior to test for a sufficient time to assure equilibrium.

ADHESION TESTS

Types of Adhesion Test

6. The adhesion strength of a cement used to bond two materials is measured by determining the force required to produce separation by failure of the adhesive. This force may be applied as (*1*) a direct tension pull in the direction normal to the adhered surfaces, (*2*) a a shearing force in the same plane as the surfaces, or (*3*) a stripping force which produces progressive separation over the adhered surfaces. It is obvious that the stripping procedure can be used only when at least one of the adhered materials is flexible. Methods, designated A, B, and C, are given for preparing and testing bonded specimens by each of these types of adhesion test. The adhesion test may also be applied, when specified, to bonded specimens which have been subjected to deteriorating influences such as accelerated aging or action of oils or solvents after their preparation and before separation but in this case full details concerning such treatment shall accompany the statement of the result of the adhesion test.

Method A. Adhesion Strength in Tension

Preparation of Test Specimens

7. (*a*) For testing cements for use in vulcanized applications, the test specimens shall be those specified in Sections 4 and 5 of the Tentative Methods of Test for Adhesion of Vulcanized Rubber to Metal (A.S.T.M. Designation: D 429),[3] except that after buffing or grinding the surfaces to be adhered, and washing them free from dirt or oil using carbon tetrachloride, they shall be coated with a uniform film of the test adhesive as near as possible 0.001 in. in thickness.

(*b*) For testing cements for use in unvulcanized applications, test specimens similar to those specified in Paragraph (*a*) shall be prepared except that the rubber cylinders used in their preparation shall be cut from vulcanized rubber and the assembly of the specimen shall be made without vulcanization in a mold. To accomplish this, the circular faces of the rubber cylinders shall be buffed smoothly and evenly to parallel planes and shall be coated with a uniform film of the test cement as near as possible 0.001 in. in thickness. With thin cements, the coating may be done with a brush, applying successive coats and allowing sufficient time between coats for evaporation of the solvent. The faces of the metal plates shall be freshly sand-blasted or ground to a dull finish with fine emery and washed free of dust and oil with carbon tetrachloride. The

metal faces shall also be coated with the test cement as in the case of the rubber cylinders. When the cement films have dried to the point where there is still aggressive tackiness but no tendency for the film to lift when touched with a finger, each rubber cylinder shall be bonded firmly by hand between the cemented faces of two metal plates and the assembly shall be clamped in a suitable loading fixture under a compressive load of 10 lb. for at least 24 hr.

Procedure

8. The prepared specimens shall be tested as described in Section 6 of A.S.T.M. Methods D 429. Care shall be taken to use a tension testing machine of capacity and sensitivity suitable for loads of the magnitude anticipated with the particular adhesive being tested. The adhesion strength shall be expressed in pounds per square inch calculated by dividing the tension load causing failure by the original area of the adhered surface which separates. With the standard test specimens the value is the load at failure divided by two. Two specimens shall be tested and the higher of the results shall be reported as the adhesion strength in tension provided they check within 10 per cent. Otherwise, additional specimens shall be tested until results are obtained consisting of the high value and one which checks this within 10 per cent. If no check of the high value is obtained when six specimens have been tested the average of all six results may be reported as the *average* adhesion strength in tension.

Method B. Adhesion Strength in Shear

Types of Test Specimens

9. Specimens for shear tests shall be of two types, namely, Type 1 lap specimens, and Type 2 sandwich specimens as shown in Fig. 1. Lap specimens shall be used when the adhesive is to be tested for bonding materials which are both extensible such as rubber, felt, or cork, or both relatively nonextensible like metal, cloth, and leather. Sandwich type specimens shall be used when one of the bonded materials is extensible and the other nonextensible. In both types of specimens, two strips of the material 1 in. in width and 5 in. in length shall be bonded over an area of 1 sq. in. with the free ends extending parallel in opposite directions to permit clamping in a testing machine. In the case of the lap-type specimens the two strips shall be bonded directly to each other by means of the adhesive being tested but in the case of the sandwich-type specimen, a 1-in. square block of extensible material having a thickness of not more than $\frac{1}{8}$ in. shall be bonded between two nonextensible strips by means of the test adhesive.

FIG. 1.—Test Specimens for Adhesion Strength in Shear.

Preparation of Test Specimens

10. The faces of the materials which are to be bonded by the test adhesive shall be buffed by hand using a wire brush, fine emery cloth or similar suitable abrasive to assure a slightly roughened surface which shall then be washed free of dirt and oil by means of oil-free carbon tetrachloride. When thoroughly

dry and without touching the surfaces after washing, the test adhesive shall be applied by brushing, spraying or spreading to form a film having a thickness of 0.001 in. as near as possible.

NOTE.—With cements of sufficiently heavy consistency to allow their use, the volumetric or dead weight cement spreaders shown in Figs. 2 and 3 may be found convenient for applying the adhesive in preparing the required specimens. With thin cements applied by means of brushing, several coats may be necessary in which case adequate drying time to permit evaporation of the solvent should be allowed between coats. Three such coats will usually be found sufficient.

Procedure

11. After the required aging period, the prepared specimen shall be clamped in the grips of a tension testing machine conforming to the requirements prescribed in Section 6 of the Standard Methods of Test for Adhesion of Vulcanized Rubber (Friction Test) (A.S. T.M. Designation: D 413),[3] using shims in the grips as indicated in Fig. 1 so that the applied force shall be in the plane of the cemented area. Care shall be taken to be certain that the specimen is properly centered and is straight in the grips

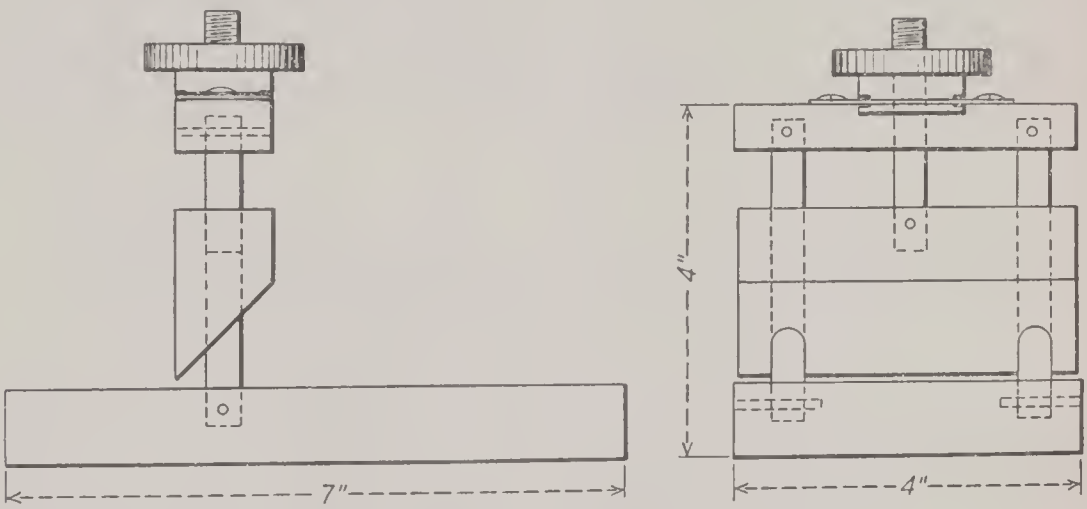


FIG 2.—Volumetric Cement Spreader.

When the cement film has dried to the point where there is still aggressive tackiness but no tendency for the film to lift when touched with a finger, the surfaces to be bonded shall be aligned carefully so that 1 sq. in. shall be adhered and pressed together firmly by hand. The specimens, resting on a smooth hard base, shall then be rolled with five complete strokes using a metal roller 1 in. in diameter applied with a hand pressure of approximately 20 lb. The specimens shall then be allowed to age for at least 24 hr. under the standard test conditions of temperature and humidity (Section 5) without any applied pressure.

When testing type 1 specimens made of extensible materials, provision shall be made to maintain the strip during the test approximately in the plane of the clamps. This may be done by holding the specimen against a plate attached to the stationary clamp. The clamps shall be separated at the rate of 2 in. per min. and the load causing separation of the specimen shall be recorded in pounds per square inch of the adhered surface which separates. (*Caution:* When shims or plates are added to the clamps, the testing machine must be adjusted for zero load with these additions or their weight must be deducted from the indicated

reading) Two specimens in each required combination shall be tested and the higher of the results shall be reported as the adhesion strength in shear provided they check within 10 per cent. Otherwise, additional specimens shall

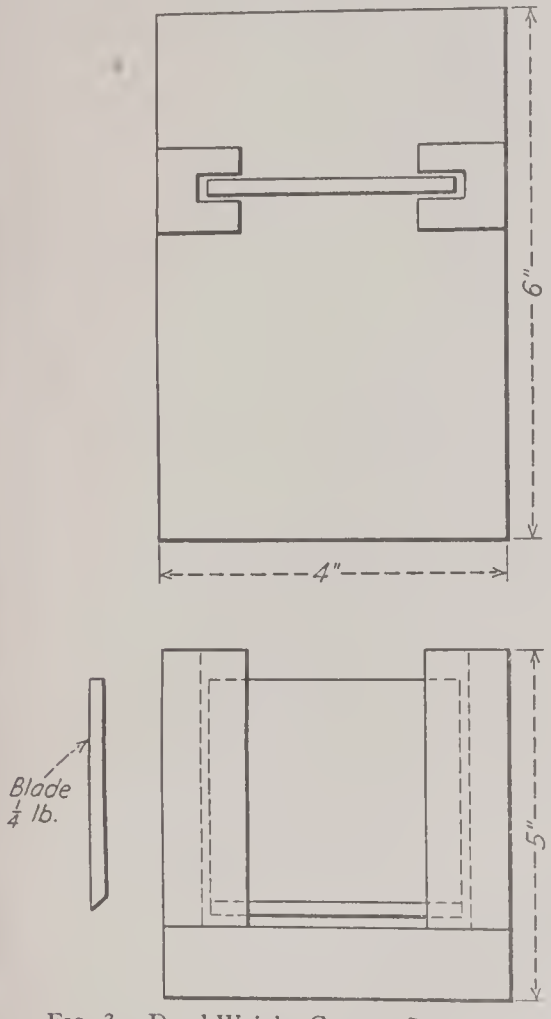


FIG. 3.—Dead Weight Cement Spreader.

be tested until results are obtained consisting of the high value and one which checks this within 10 per cent. If no check of the high value is obtained when six specimens have been tested, the average of all six results may be reported as the *average* adhesion strength in shear.

Method C. Adhesion Strength by Stripping Method (Friction Test)

Preparation of Test Specimens

12. A strip at least 6 in. in length by 1 in. in width of flexible material shall be bonded by means of the test cement except for 2 in. at one end to a strip 12 in. in length by 2 in. in width of the other material which is to be adhered. The center lines of the two strips shall be superimposed. The surface to be bonded shall be properly prepared, for example, by buffing, washing with carbon tetrachloride, drying and coating with a film of the test cement 0.001 in. in thickness (Note), uniting, rolling down, and aging as specified in Section 10 for shear test specimens.

NOTE.—In the case of porous material, the thickness of the cement film shall not be specified.

Procedure

13. The test specimens shall be placed in a tension testing machine by clamping the free end of the 2-in. wide strip in one grip and turning back the free end of the flexible 1-in. wide strip and clamping it in the other grip. The testing machine and the procedure used shall conform to that specified under the machine method for strip specimens in Sections 6 and 7 of A.S.T.M. Methods D 413. The autographic chart obtained constitutes the report of the test but the value of the adhesion shall be determined by drawing on the chart the best average line between the maximum and minimum load values. The load so indicated, expressed in pounds per inch of width for separation at 1 in. per min., shall be considered as the adhesion strength by the stripping method. For the evaluation of each cement sample, two samples shall be prepared and tested and the higher average load obtained shall be reported as the adhesion strength of the sample.

BONDING RANGE

Type of Test

14. The test for bonding range is intended for use in determining the most

suitable drying period for use with the test cement after application and before bonding the materials in order to obtain the maximum initial bond strength. A series of type 2 shear adhesion test specimens (Fig. 1) is prepared using the test cement and allowing it to dry for different known periods before uniting the materials. These specimens are cemented, dried, bonded, and tested for adhesion strength in shear according to a definite time schedule. The drying period which results in the highest shear adhesion value is the optimum bonding range for the cement being tested.

Preparation of Test Specimens

15. The test specimens shall be type 2 shear adhesion test specimens each made from two strips of aluminum alloy 1 in. in width by 5 in. in length bonded by the test cement to a block of heavily compounded rubber 1-in. square by $\frac{1}{8}$ in. in thickness having a durometer hardness of 75 to 85. The specimens shall be prepared in duplicate as specified in Section 10 except that the application of the cement shall be so scheduled that successive pairs of specimens may be dried 1, 3, 5, 10 and 20 min. before bonding and each tested exactly 3 min. after making the bond. After the first 20 min. of drying time, additional intervals of 20 min. to a maximum of 2 hr. shall be used.

Procedure

16. The test specimens prepared according to the prearranged schedule shall be tested as specified in Section 11 three minutes after making the bond and rolling them. The force in pounds required to separate the rubber from the metal shall be recorded for each specimen and the maximum value selected. The drying time used for cementing that specimen shall be reported as the optimum bonding range. If the maximum value is obtained with a specimen dried for 2 hr., the optimum bonding range shall be reported as 2 hr. or more.

SOFTENING POINT

Type of Test

17. The test for softening point is intended for use in determining the temperature at which the cement softens sufficiently to provide an ineffective bond. It consists of subjecting type 2 shear adhesion test specimens (Fig. 1) under a definite shearing load for a specified interval to successive increments of temperature until the bond fails. The temperature at which failure occurs is taken as the softening point. Obviously, the test is useful primarily for comparisons between different cements as the adhesion strength may be seriously reduced at temperatures below the softening point.

Preparation of Test Specimens

18. Type 2 shear adhesion test specimens (Fig. 1) using the test cement shall be prepared in duplicate as specified in Section 15, except that the drying time shall be that determined as the optimum bonding range and the specimens shall be aged before test at least 24 hr. under the standard conditions of temperature and humidity (Section 5) without applied pressure.

Procedure

19. The test specimens shall be hung with one metal end of each attached to a suitable support in an electric oven complying with the requirements prescribed in Section 4 of the Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method (A.S.T.M. Designation: D 573).[3] A weight of 1 lb. (Note) shall be attached carefully without shock to the lower end of each specimen. In attaching the weight and suspending the specimens, suitable clamps and shims shall be used to maintain the specimens in a vertical position and to distribute

the load uniformly over the test specimens. The oven temperature shall be maintained at 100 F. for 15 min. and then increased 15 F. each 20 min. until the rubber separates from the metal. The temperature at which the bond fails shall be reported as the softening point of the test cement used in the specimen.

Note.—With certain special adhesives, it may be desirable to employ very much larger loads than the 1 lb. specified. In these cases, the method may be modified accordingly but any such change must be clearly indicated with the reported results.

COLD FLOW

Type of Test

20. The cold flow test is intended to evaluate the tendency for surfaces bonded by means of the test cement to slip or be displaced when subjected to difference in stress for a sustained period. This yielding is considered to be due to cold flow of the adhesive. The test consists of subjecting a bonded specimen to a specified load for a prolonged period and measuring the elapsed time for failure of the bond.

Preparation of Specimens

21. Type 2 shear adhesion test specimens (Fig. 1) using the test cement shall be prepared in duplicate as specified in Section 18.

Procedure

22. The test specimens shall be hung with one metal end of each attached to a suitable support and a weight of 1 lb. (see Note, Section 19) shall be applied carefully without shock to the lower end of each specimen. In attaching the weight and suspending the specimens, suitable clamps and shims shall be used to maintain the specimens in a vertical position and to distribute the load uniformly over the test specimens. The loaded specimens shall be maintained at the standard test conditions of temperature and humidity (Section 5) and observed hourly for 24 hr. or until the time of failure which shall be recorded as the bond failure time in the cold flow test. If no failure occurs in 24 hr., the load shall be increased to 1.5 lb. and the specimens observed for an additional 24 hr. as before. If the bond failure time is over 24 hr. with the 1-lb. load and a second period with the heavier weight is required, the report shall indicate a bond failure time of over 24 hr. under 1 lb. and also shall state the added time under 1.5 lb. required for failure.

VISCOSITY

23. The viscosity of the cement shall be determined in accordance with the Standard Methods of Test for Viscosity and Total Solids Content of Rubber Cements (A.S.T.M. Designation: D 553),[4a] using a duplicate specimen for checking.

STABILITY

Type of Test

24. The stability test provides a means for estimating the relative life of cements in usable form prior to application. When stored, even in containers, many cements jell because of slow vulcanization at ordinary temperatures or other physical or chemical changes and become unusable as adhesives. These changes are evidenced by change in viscosity of the cement. The test consists of subjecting a series of specimens of the cement under specified conditions to an elevated temperature and determining the viscosity at intervals until a marked change occurs which time is taken as a measure of the stability of the cement.

Procedure

25. Twelve specimens of 250 ml. each of the test cement shall be measured into

[4a] Appears in this publication, see Contents in Numeric Sequence of A.S.T.M. Designations at front of book.

glass test tubes approximately 1½ in. in diameter and 9½ in. in length so that each tube is approximately two-thirds full. The tubes shall be fitted with small reflux condensers and placed in a constant temperature water bath at 140 F. The viscosity of the test cement shall be determined and recorded at the start of the test as specified in Section 23. After one week in the water bath, two of the tubes shall be removed, cooled to room temperature and measured for viscosity as at the start of the test. If these specimens have jelled or show a marked increase in viscosity, all of the specimens shall be discarded and new ones started which shall be checked in pairs daily. If the original specimens show no appreciable change in viscosity, the heating shall be continued for five additional days with two specimens taken out each day for viscosity determinations until marked change in viscosity occurs or the cement jells. All viscosity results shall be recorded and reported. The number of days of heating to produce the change shall be reported as the stability number of the cement.

NOTE.—With some special cements made from synthetic rubbers, the viscosity may increase progressively and the cement may become unusable before showing any sudden marked change indicating jelling. In such cases, it may be desirable to test a series of specimens daily in the specified manner and plot the viscosity *versus* time. The resulting curve may be used as the report and no stability number stated. The evaluation of the usability of the cement will depend upon the purpose for which it is intended and the materials to be bonded.

COLD BRITTLENESS

Type of Test

26. The test for cold brittleness is intended for use in evaluating and comparing the resistance of cements to cracking or chipping when bent at low temperatures. A coat of the test cement on an aluminum strip is cooled at specified temperatures for a definite time after which the strip is bent in a prescribed manner and examined visually for cracking or chipping of the cement coat.

Procedure

27. Six strips of aluminum alloy 1 in. in width by 3 in. in length by 0.040 in. in thickness shall be cleaned and cemented on one side forming a film of adhesive 0.001 in. in thickness as specified in Section 10. The film shall completely cover the one side of the metal. After being aged for at least 3 hr. under the standard atmospheric conditions (Section 5), two of the strips shall be placed in cold atmospheres at each of the following temperatures: 0 F., − 20 F., and − 40 F. The strips shall be maintained at these temperatures for 30 min. and then immediately bent double over a mandrel ⅜ in. in diameter with the cemented side out and without removing them from the cold atmosphere. The coatings shall then be examined for visual signs of cracking or chipping. A qualitative statement of the results with the cement at each temperature shall be reported.

WEIGHT PER GALLON

Apparatus

28. The weight per gallon of a cement shall be determined by use of a pycnometer calibrated for a volume of 83.3 ml. at 77 ± 5 F.

Procedure

29. The pycnometer shall be weighed in grams accurately to three significant figures. It shall then be filled with the calibration volume of the test cement which shall have been stirred until homogeneous and shall be free from air bubbles and the filled weight in grams shall be recorded. The weight per gallon of the cement shall be calculated by

dividing the difference in weight of the filled and empty pycnometer by 10.

PLASTIC DEFORMATION

Type of Test

30. The test for plastic deformation is applicable only to heavy adhesives such as doughs, sealers, putties, etc. It is not suitable nor of use in the case of liquid adhesives.

Procedure

31. Two small spheres of the heavy adhesive approximately 1 in. in diameter shall be prepared by rolling in the hands. These spheres shall be placed on small watch glasses and heated in an air oven at 250 F. for 1 hr. The spheres shall then be removed and examined for flow or distortion. If the spheres have suffered any marked change in shape, the adhesive shall be reported as subject to plastic flow in the deformation test.

REPORT

Report

32. The report shall include the following:

(*1*) Complete identification of the test sample of cement,
(*2*) Date of test and date of manufacture if known,
(*3*) Description of special materials used,[5]
(*4*) All observed and recorded data, and
(*5*) Statement of the results obtained in each of the tests required.

[5] This item was added editorially, June, 1948.

American Society for Testing Materials

Application for Membership

The undersigned hereby applies for $\left\{\begin{matrix} \textit{sustaining} & \textit{individual} \\ \textit{company} & \textit{junior} \end{matrix}\right\}$ membership in the American Society for Testing Materials including subscription to ASTM Bulletin. If this application be duly approved, he agrees to be governed by the Charter and By-laws of the Society and to further its objects as laid down therein.

NAME .....
(Firm, Organization or Individual Applicant)

ADDRESS FOR MAIL .....
(If other than below)

..... ZONE .....

NATURE OF BUSINESS .....

NAME ..... TITLE .....
If company membership, indicate above the name and title of individual who will exercise membership privileges.

NAME OF ORGANIZATION .....
If individual membership, indicate above the name of organization with which applicant is affiliated.

ADDRESS OF ORGANIZATION .....

APPLICANT'S TITLE OR OCCUPATION .....

DATE OF BIRTH .....

GRADUATE OF, OR ATTENDED .....
Name of College or University

YEAR ..... DEGREE, OR COURSE .....

Recommended by (TWO MEMBERS) .....
.....

Application for membership should be mailed to
AMERICAN SOCIETY FOR TESTING MATERIALS—1916 RACE ST., PHILADELPHIA 3, PA.

1950 D-14

AMERICAN SOCIETY FOR TESTING MATERIALS

* * * * * * * * *

EXTRACT FROM CHARTER

1. The name of the proposed corporation is the "American Society for Testing Materials."
2. The corporation is formed for the promotion of knowledge of the materials of engineering, and the standardization of specifications and the methods of testing.

EXTRACT FROM BY-LAWS

ARTICLE I. *Members and Their Election*

SECTION 1. The Society shall consist of Individual Members, Company Members, Sustaining Members, Junior Members, Student Members and Honorary Members.

SEC. 2. An Individual Member shall be a person, technical or scientific society, college or university or department thereof, library, government bureau or department, or such other organizations as the Board of Directors may deem as appropriately coming under this classification.

SEC. 3. A Company Member shall be a company, corporation, firm, industrial or trade association, or such other organizations as the Board of Directors may deem as appropriately coming under this classification.

SEC. 4. A Sustaining Member shall be an Individual Member or Company Member who wishes to support and participate in the work of the Society through the payment of larger dues.

SEC. 5. A Junior Member shall be a person less than twenty-seven years of age. A Junior Member shall have the same rights and privileges as an Individual Member, except that he shall not be eligible for office. His status shall be changed from Junior Member to Individual Member at the beginning of the fiscal year next succeeding his twenty-seventh birthday.

ARTICLE V. *Meetings*

SECTION 1. The Society shall meet annually, for the transaction of its business, including actions on standards, at a time and place fixed by the Board of Directors. Twenty-five members shall constitute a quorum.

SEC. 2. Special meetings may be called whenever the Board of Directors shall deem it necessary, or upon the written request of 25 members to the President.

ARTICLE VIII. *Dues*

SECTION 1. The fiscal year shall commence on the first day of January. The annual dues*, payable in advance, shall be as follows: For Individual Members, $18; for Company Members, $50; for Sustaining Members, $150; for Junior Members, $9; for Student Members, $2. Honorary Members shall not be subject to dues.

SEC. 2. The entrance fees, payable on admission to the Society, shall be $10 for Individual Members, Company Members and Sustaining Members, and $5 for Junior Members. Student Members shall pay no entrance fee. The fee payable upon transfer from one class of membership to another, shall be the difference between the corresponding entrance fees.

SEC. 5. Any person elected after six months of any fiscal year shall have expired, may pay only one-half of the amount of dues for that fiscal year; but in that case he shall not be entitled to a copy of the Proceedings for the current year.

*NOTE—Of the annual dues $2.00 is for subscription to ASTM BULLETIN.

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